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EXTRACTS FROM THE REPORT

OF

5-849

Her Britanic Majesty's Commissioners,

APPOINTED TO INQUIRE INTO

THE CONDITION AND MANAGEMENT OF LIGHTS, BUOYS, AND BEACONS.

Submitted March 5, 1861,

AND

PRESENTED TO BOTH HOUSES OF PARLIAMENT BY COMMAND OF HER MAJESTY.

Republished for the use of the U. S. Light-House Establishment.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

NEW-YORK.

EXTRACTS.

*　　*　　*　　*　　*　　*

Of all the lights under the general authorities, and about half of those under the local authorities, your Commissioners have obtained full returns, which will be found at length in the second volume.*

The lights on shore, for which returns have been received, are classified in the following table:

Authority.	Light-houses.	Catoptric.	Dioptric or catadioptric.	Apparatus not stated.	Order of dioptric apparatus.					
					1st.	2d.	3d.	4th.	5th.	6th.
England—Trinity House	82	51	31	......	20	8	......	1	......	2
Local	49	35	14	......	1	1	3	4	2	2
Scotland—Commissioners of Northern Lights	46	14	32	......	16	4	......	9	......	......
Local	24	13	3	8	......	......	......	......	......	......
Ireland—Ballast Board	69	51	18	......	10	1	4	3	......	......
Local	6	......	3	3	......	......	......	......	......	......

Position.

The index map at the end of Vol. I* shows the *position* of the light-houses in the United Kingdom, and on a portion of the French, Belgian, Dutch, and Norwegian coasts. Very few complaints are made as to the position of light-houses by mariners, or the agents of Lloyd's, and those which are made are generally confined to three or four sites.

Sufficiency.

It will be seen, by looking at the map, that the number is sometimes *insufficient*, because vessels might be within a very short distance of some parts of the coast, and beyond the estimated range of any light-house, even in clear weather; for instance, at Great Orme's Head, on the approach to Liverpool.

The circles of light on the index map* are taken from the map published by the Board of Trade, and represent the column in the Admiralty List of Lights headed "*Miles seen in clear weather;*" but from the evidence before us, and from our own observations, the lights are not uncommonly seen at much greater distances. Any attempt to make lights so brilliant or so numerous as that one at least should be visible in fogs which are dense enough to obscure the sun, would necessarily fail; but any increase in the brilliancy of the lights will increase their range in hazy weather, and make them more efficient; and their number ought to be such as to insure that one or more may always be within sight of a ship approaching a danger in ordinary weather.

The west coasts of Scotland and Ireland are still *insufficiently* illuminated; and the channel islands lying near the track of ships bound up channel, and surrounded by rapid tides, have been left in a state of blameable darkness, although a light is now being erected on the Hanosi

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*Of the Parliamentary Report.

Rocks, on the west coast of Guernsey. A reference to the index map will best show the *positions* where the *number* of lights is *sufficient* or *insufficient.*

Number and position, compared with foreign countries.

It will be observed, as respects *number* and *position* of lights, that the British coasts are *not* so well guarded as the French, for the lights are purposely so placed on the coasts of France as to "cross their fire."

This may also be tested by comparing the proportion between the number of lights and the amount of coast line in England, Scotland, and Ireland, with the proportion between the number of lights and the coast line in France. The measurement of the coast line and of the islands in the respective countries is given in a table in Vol. I, p. 222; the number of light-houses is taken as before from the Admiralty List. From these data the following table is constructed:

Country.	Number of light-houses on shore.	Coast line—Nautical miles.	Proportion.
England	171	2,405	1 for 14.0 miles
Scotland	113	4,469	1 for 39.5 "
Ireland	73	2,518	1 for 34.5 "
France	224	2,763	1 for 12.3 "

Hence, it appears that the light-houses in France are more than three times as numerous, compared with the amount of coast, as in Scotland; but a considerable allowance must be made for the very large amount of mileage afforded by the Scottish islands and the bays on the Irish coast, which do not require a commensurate amount of lighting, as a light on an island or on one side of a channel will often obviate the necessity of a light on the main land, or on the other side. The lights in France appear to be nearly three times as numerous, comparatively speaking, as those in Ireland; but if to the seventy-three Irish light-houses be added the five floating lights, the discrepancy is somewhat reduced. In England, too, there seems at first sight to be a somewhat smaller provision made for illuminating the coasts than in France, yet if the forty-one English floating lights be added to the one hundred and seventy-one light-houses, as indeed justice requires, England will be found to provide a light for every 11.37 nautical miles of coast, while France furnishes one for only every 12.3 miles.

As to the *position* of lights in France and in England, there is this notable difference: The English lights have been steadily and gradually increasing in *number* during the last two centuries and a half, additional lights having been placed, from time to time, wherever the interests of commerce demanded, and a sufficient pressure was exerted; while, on the contrary, the French lights were very few till 1825, when a grand comprehensive plan was undertaken of erecting a large *number* of additional lights, on what were considered the best *positions,* and of remodelling the whole system.

The coasts of the United Kingdom are better guarded than those of Holland, Norway, or perhaps any other country, excepting France.

QUALITY OF LIGHTS.

Quality.

The quality of a light depends mainly on the following points:

1. *The character of the source of light.*
2. *The character of the apparatus, by which the light is directed to where it is needed.*
3. *The adaptation of the source of light and the optical apparatus to one another, with a view to the requirements of the locality.*
4. *The distinction of one light from another.*

1. *The Character of the Source of Light.*

Source of light.

It is the invariable practice of the three general light-house authorities in England, Scotland, and Ireland, to derive it from the combustion of colza oil. Where metallic reflectors alone are used, the lamp is on the Argand principle; but where lenses are employed, a large central lamp is resorted to. The Argand burners vary in number from one to thirty, and the central lamps differ in the number of concentric wicks. The Trinity House and Ballast Board, at the time of the commencement of our inquiry, used fountain lamps, and never employed more than three of the four concentric wicks, (see Vol. I, p. 63,) while the Scotch Commissioners retained a fourth in first-order lights. The lamps in Scotland being mechanical lamps, were found also to cause a considerably greater consumption of oil, (as five to three,) and therefore the production of a higher and more powerful flame than was produced in England or Ireland.

Mechanical lamps preferred.

The local authorities also generally employ oil lamps, but the oil burnt is not always colza. Liverpool, for instance, prefers olive oil; and the Admiralty and Newhaven still retain the more expensive sperm, the use of which was abandoned for various reasons by the general authorities some years since. Gas is also burnt in many harbor lights, and in the beacon-light at Northfleet, under the management of the Thames Conservancy; and in that, as in many other cases, and in the United States, with a very satisfactory result.

To the subject of the height of the flame your Commissioners have given much consideration. It will again be alluded to in this report; but they are glad to be able to put on record here that the Elder Brethren of the Trinity House have lately admitted the propriety of returning to the use of the fourth wick, and are now making experiments with a view to ascertain the best possible description of mechanical lamp.

Your Majesty's Commissioners, however, are of opinion that the science of light-house illumination is in a transition state, and capable of further development. We have conversed with a man who was actually employed in his youth in burning coal fires at Harwich for directing ships at sea; in fact, the last coal light, that at St. Bees, was only extinguished in 1822. The use of oil does not seem to date back beyond 1730; and we now find inventions under trial which promise to transcend far the powers of even the four-wicked mechanical lamp in producing light. Gas might probably be advantageously employed in other than harbor lights, where it is now frequently used.

A greater use of gas approved of.

Electric light approved of.

An electric light, which is produced between carbon points by the revolution of magnets fixed on wheels worked by a steam-engine, has been tried with great promise of success by Professor Holmes at the South Foreland, and is to be further tried at Dungeness, or at the Start.

Another electric light, produced by galvanic action in a stream of mercury, has been exhibited by Professor Way, and proposed for adoption in light-houses.

Several modifications of the lime light, produced by an oxyhydrogen flame playing on a surface of prepared lime, have been exhibited, and are commonly used in lecture-rooms and elsewhere; and these are now proposed for use in light-houses. And the least powerful of these surpasses the best oil lamp in brilliancy, as the oil lamp surpasses the open coal fire.

When any of these are so perfected as to make their action certain, the optical apparatus now used, and made to suit large flames, will be out of date as much as the large tinned reflector which was first erected behind a large coal fire on the Tour de Cordouan, and which was then considered a great advance in science. Optical apparatus, to suit a very small and exceedingly brilliant source of light, $\frac{1}{8}$ of an inch long, may be of small size, and finished and adjusted with all the accuracy of a telescope. Thick lantern bars, and the comparatively clumsy and costly brass fittings, which now interfere with light, may perhaps be done away with, and then the cost of apparatus may possibly be as much diminished as the quality of the light is improved.

2. *The Character of the Apparatus by which the Light is directed to where it is needed.*

Character of apparatus.

It may be well to state shortly what is aimed at in constructing optical apparatus for light-houses, before proceeding to show how far the object has been attained.

From any given source of artificial light, such as a point in the flame of a lamp, rays proceed in every possible direction until obstructed. The fact may be familiarly proved by observing that the light of a table lamp falls on every part of the spherical ground glass shade, except where the metal of the burner interferes.

The object of light-house illuminating apparatus, whether constructed of glass or of metal, is to bend the rays which would naturally proceed in straight lines and illuminate a hollow sphere, so that those which would otherwise be wasted may be used and fall on points where they may be seen at sea.

Taking the spherical lamp shade as an illustration, those rays from the lamp which illuminate the upper portion should be so bent downwards as to double the illumination of the lower half, if the light is intended to be a fixed light, seen all around, and from the horizon to the base of the light tower; and all the rays should be further bent laterally, if it is desired to illuminate a narrow strip of sea, extending from the horizon to the base of the light-house; or the rays may all be collected and thrown on one or more spots, of larger or less size, wherever the light is wanted.

These last objects are sought to be attained in fixed lights placed at the end of narrow passages, and in revolving lights; and these last are made visible all around, by causing the lenses, reflectors, &c., to revolve about the source of light, or with it about a centre.

The better the machinery and apparatus is contrived and executed, and adapted to the situation, the more the light produced from a given source is rendered available by directing it properly; and the less it is wasted by absorption, dispersion, or improper direction, the better is the *quality* of the apparatus, and the greater the economy of the fuel consumed in producing the light. It must be borne in mind that the economy in the fuel consumed, is in exact proportion to the light used, and the waste to the light wasted; that light which is thrown on the sky is equivalent to oil thrown away.

There are two principal means by which it is sought to throw the light in the desired direction. The one is by silvered parabolic reflectors, and is called the "catoptric" system; the other is by lenses of peculiar construction, and is called the "dioptric" system. Sometimes the two systems are combined together, as in the ordinary "catadioptric," and in Mr. Stevenson's "holophotal" arrangement.

These silvered reflectors even are comparatively modern inventions, dating, in fact, from the close of the last century, and it is not forty years since the first dioptric apparatus was constructed by Fresnel, in France, and lenses have only gradually replaced the reflectors in our country. The lenticular system, as now developed, varies greatly from that first proposed, and modifications are continually suggested. Manufacturers both at home and abroad have invested large sums in machinery and in improving the quality of glass; and where so much thought is bestowed, it is reasonable to anticipate further improvement.

The table already given, shows the proportion between the catoptric and dioptric lights at present existing in the three kingdoms. It will be seen that the principle of refraction is generally adopted in Scotland, while that of reflection still holds the numerical preponderance in England and Ireland; but it should be borne in mind that the lighting of the Scottish coasts is of a later date than that of the English.

It has been generally assumed that the dioptric is preferable to the catoptric system; but while your Commissioners do not controvert this opinion, they have conclusive evidence that many of the catoptric lights in England are not only excellent in themselves, but exceed in efficiency the dioptric lights on its shores.

* * * * * * *

We are, however, of opinion that this preference of the large reflecting lights arises not from any inherent superiority of the catoptric system, but from the fact that the dioptric principle, owing to errors of adjustment, has never yet been allowed a full and fair chance in the United Kingdom, and a saving of oil has also been unfortunately attempted in various ways, chiefly by the use of inefficient fountain lamps in all the dioptric lights, with the exception of those in Scotland, which has not been considered in the great revolving catoptric lights with thirty Argand burners. This subject will be reverted to in the following section:

3. *The Adaptation of the Source of Light and the Optical Apparatus to one another, with a view to the requirements of the locality.*

Adaptation of the source of light and optical apparatus.

This ought to be considered with reference to the object which it is proposed to effect, namely, in most cases, to send a bright light to the sea-horizon, and at the same time to illuminate sufficiently the nearer portions of the sea.

* * * * * * *

The source of light never is one luminous point, but a figure having length, breadth, and depth, and is composed of a vast number of luminous points, some of which are placed at considerable distances from others. The vertical and lateral divergence of light-house beams depends in a great measure on the *size* and *shape*, as well as on the *position* of the source of light placed in the apparatus; and though works on light-house illumination often mention the flame as if all its parts sent some portion of light to all places from which the light can be seen, such is not the fact. Light-house apparatus, like any other lenses or reflectors, form within the apparatus an image of the landscape outside, with greater or less accuracy; and when the flame is so placed inside as to coincide with the image formed by the apparatus, rays will proceed from points in the image to corresponding points in the landscape, along the same paths which were followed by the rays which, starting from without, formed the image within; and different parts of the flame do in fact illuminate different parts of the sea and sky.

A photographic camera gives a good illustration of this fact. The lens can be so placed as to project an inverted image of a landscape on a glass screen. If a lamp is placed instead of the ground glass, its light will be seen through the lens from those places whose image corresponds with the position of the lamp, and from no other places. And, in like manner, the best and most brilliant light may be so placed within a light-house as to be invisible at sea, when the apparatus itself is well constructed.

A mariner, when he looks from a given position, through a dioptric apparatus of the first order, at a light-house lamp with four concentric wicks, is not looking at a single radiant point placed in the common focus of the instrument. His eye is affected by rays proceeding from a vast number of radiant points, variously situated, in different parts of eight different sources of light, of various forms and dimensions, and placed at different distances from the apparatus, some within and others beyond the focus for parallel rays. Each of these sources of light is viewed in many different directions through as many different pieces of glass; and every piece of glass, taken separately, is in itself a complicated optical instrument, with curves, angles, and a focus of its own, contrived by its inventor for a particular purpose, and to form part of a definite whole.

As a light-house flame is composed of many irregular figures, there are probably no two spots equally illuminated by a light-house beam.

When such is the complicated nature of the instrument, and when all its parts have been contrived and made for a particular purpose, any new adjustment or arrangement of these different parts, after they have been so made and put together, must be skilfully and scientifically done, if it is to be efficient.

It seems to follow, therefore, that the altitude as well as position of every new light-house, and the size and shape of the light to be placed in it, ought to be known and fully considered before the apparatus is made and put together.

A beam of a given divergence, with its axis in the plane of the geometrical horizon, or at right angles to a vertical line, must become invisible from the sea if the light is raised to a sufficient height above the earth, whose surface is curved; and the more nearly it approaches that height the less serviceable will it be, because the greater wil be the amount of light thrown on the sky.

It is found in practice that the fact agrees with the theory, and that much light is now wasted, especially in high light-houses, with low flames.

Present catoptric lights faulty.

The experiments tried by our secretary at the Point of Ayre, and at Bidston, and our observations made on the Gunfleet light, will show that catoptric lights, as at present constructed, do not fulfil perfectly the conditions required; that is to say, they throw only a portion of the light produced, on the sea, where it is wanted. On the contrary, a very large portion is thrown on the sky; and as the light at the Point of Ayre is revolving, and shows all around, it illuminates the highest hills in the Isle of Man, and great part of the light produced is wasted.

Present dioptric lights faulty.

Again, as regards dioptric lights, as at present used in England and Ireland, it has been found that great improvements are possible. A large portion of the light produced even in those which are best made is now wasted. In some cases a part of the light is thrown too high, in others it shines on the land. In some the fault appears to arise from a want of consideration of the requirements of the locality, in others from want of adjustment in apparatus ordered with insufficient specification by the authority giving the order—originally constructed by a manufacturer without reference to elevation—and finally placed by the authorities, without considering the construction, at an elevation for which it was not fitted. There are also cases of faulty manufacture, involving bad glass and inaccurate grinding.

These defects were early noticed by your Commissioners, and we found them to exist in light-houses abroad as well as at home; and one of our first acts, on arriving at these conclusions, was to frame the questions of Circulars IX and X, and address them to such scientific men as might be supposed capable of giving a valuable opinion, and to manufacturers of light-house apparatus.

Astronomer Royal.

But your Majesty's Commissioners thought it highly desirable that the opinions which they had themselves formed, and those which they might elicit, should, if possible, be confirmed by the highest available authority.

We accordingly applied to the Astronomer Royal for his valuable aid; and we wish here to express our high sense of the kindness with which Professor Airy acceded to our wishes, and of the advantage which we have derived from his assistance. Our wish was that the Astronomer Royal, a high authority on mathematics and optics, should have the best opportunity of forming an opinion as to the adjustment of dioptric apparatus, and with that view he was informed of what had been observed by us; the specifications prepared by the Light-house Boards in ordering dioptric apparatus were also laid before him; and he was requested to accompany your Commissioners, and to inspect dioptric light-houses at home and abroad.

Professor Airy readily complied with these requests; he gave his time and attention gratuitously; and the result of his personal observations are stated by himself in his reports and letters to the chairman.

Start Light-house, &c.

The first light visited by your Majesty's Commissioners in company with the Astronomer Royal was the Start. An account of the proceedings will be found in Vol. I, p. 46,* and our subsequent proceedings with reference to the adjustment of illuminating apparatus are described on the pages which follow. These include special visits to the Forelands, St. Catherine's Head, the Needles, Ramsgate, and Shoreham, the French lights of Calais, Grisnez, and Ailly; meetings with light-house authorities, and other scientific men, at the North Foreland and Whitby; a visit by the Astronomer Royal to Girdleness, in Scotland, and another by your Commissioners to Minehead and Dungarvon, in Ireland, and experiments at the works of Messrs. Chance, at Birmingham.

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* Of the Report.

Summary of defects.

The result of all these proceedings may be summed up in a few words:

1. The dip of the sea-horizon below the geometrical horizon has never, in the United Kingdom, been properly taken into account in dioptric lights, although, where the light is high above the surface of the sea, as, for instance, two hundred and forty feet at Whitby, this makes the important difference of 0.16 inch in the proper position of the flame.*

2. The various pieces of which a dioptric illuminating apparatus is composed have not even been adjusted to the flame and the geometrical horizon with sufficient accuracy. The result of this has usually been to send a most unnecessarily large amount of the rays upward to the sky, as may be easily determined for each individual piece of glass by the plan of internal observation devised by Mr. Campbell, the Secretary of the Commission.† Professor Holmes has stated that out of ninety-six prisms at the South Foreland light, which he examined from outside, he found ninety-four faulty in this respect.

Consumption of oil insufficient; wicks too few; lamps imperfect.

3. The flame in English and Irish lights is kept far too low, owing to the use of only three wicks and of the fountain lamp, which burns on an average only four hundred and seventy-four gallons of oil annually in England, and four hundred and forty-two in Ireland. This has the double disadvantage of diminishing the upper part of the flame, which is of the greatest service in illuminating the sea, and of lowering the section of greatest luminosity in the flame below the focus of the lens, thus causing the brightest portion of the light to be in that portion of the same which always of necessity sends its rays above the horizon.

This fault was not found to exist in the lights under the Northern Commissioners, who make use of a mechanical pump lamp, which burns on an average seven hundred and ninety-four gallons of oil annually, and produces good flames of about double the height of those in England or Ireland.

Other remarks on the want of reflectors on the land side of the apparatus, on the injurious effect of the shoulder of the lamp-glass, on the erroneous position of astragals, on the want of filters, medicine chests, clocks, signals for day, night, during fogs, &c., will be frequently found among the personal observations of your Commissioners, and in the special report on the Whitby lights.

The Elder Brethren of the Trinity House are now alive to the importance of these subjects, as far as relates to their works, and the scientific adviser to whom they apply in such cases, Professor Farraday, has now directed his attention to them; and your Commissioners anticipate that the defects which have been pointed out will soon be remedied, now that attention has been called to them, and after their existence has been demonstrated by so many experiments and observations.

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* The flames maintained in the Scotch first order light-houses appear to have their sections of maximum luminosity so high as in some cases to compensate for this neglect, so far as the lenses are concerned.

† It has since been ascertained that this plan was adopted by M. Fresnel in adjusting the mirrors above the lenses of his apparatus.

4. *The Distinction of one Light from another.*

Distinction of lights.

Various means are resorted to to effect this important object. Some lights are fixed, others are revolving; some are white, others are colored. The following tables, drawn up from the Admiralty List of Lights, will indicate the extent to which this distinguishing of lights is carried in the three countries:

Character.

Country.	FIXED.	REVOLVING, FLASHING, INTERMITTENT.											
			Interval between maxima of brilliancy.										
	No. of.	No. of.	5 seconds.	10 seconds.	15 seconds.	20 seconds.	30 seconds.	45 seconds.	1 minute.	1½ minute.	2 minutes.	3 minutes.	4 minutes.
England—Trinity House	63	19	0	1	1	5	3	0	4	1	3	0	1
Local	60	4	0	0	0	0	3	0	0	0	1	0	0
Scotland—Northern Commissioners	23	23	3	2	1	0	3	0	7	0	5	2	0
Local	60	3	0	0	0	0	0	0	3	0	0	0	0
Ireland—Ballast Board	55	14	0	1	1	0	1	1	4	1	4	1	0
Local	8	2	0	1	0	0	0	0	0	0	0	1	0
Total	269	65	3	5	3	5	10	1	18	2	13	4	1

Many of these distinctions, again, are susceptible of sub-division. For instance, some lights designated "fixed and flashing," give a constant light, besides the waxing and waning light, with intervals of darkness, while others alternate between brilliancy and total darkness. Again, the relative duration of light and darkness may be different, although the intervals between the maxima of brilliancy may be the same.

Color.

Country.	White.	COLORED.					
		White and red.	Red.	Green.	Red and green.	Red, white, and green.	Blue.
England—Trinity House	64	13	5	0	0	0	0
Local	31	4	20	4	2	1	2
Scotland—Northern Commissioners	32	10	3	0	0	1	0
Local	31	5	25	1	1	0	0
Ireland—Ballast Board	49	16	3	0	0	1	0
Local	4	3	3	0	0	0	0
Total	211	51	59	5	3	3	2

Of the colored lights, all are fixed, with the exception of fourteen revolving lights, which show red and white alternately, and three simple red lights which revolve.

The use of colored lights has this advantage, that the color is only obtained by absorbing a large portion of the rays emitted from the lamp, namely, those of other colors, and, therefore, the required intensity is only obtained by consuming a larger amount of oil. Again, green and blue lights are highly objectionable for light-houses, except for very short ranges, on account of the readiness with which rays of those colors are absorbed by the atmosphere if it is at all misty. Red rays, on the contrary, penetrate peculiarly well, and, as your Commissioners have witnessed, furnish an admirable and most useful means of distinction—one which, in their opinion, is not enough resorted to, a deficiency which will be at once apparent on a glance at the above table, especially in reference to the Trinity House, or at the index map projected by our secretary; but at the same time we consider that it is highly desirable, wherever practicable, to make red lights revolve, in order that the greater quantity of light thus brought into one direction may counteract the absorption of rays due to the colored glass. Indeed, your Commissioners would willingly see, as far as practicable, all lights in prominent situations revolving, since a greater range in dull weather is thus obtained, and there is less chance of mistaking them for ships' lights, which are now often of great brilliancy, or of mistaking ships' lights for them. At the same time it should be borne in mind that, at the rate at which ships are now propelled, it is desirable (in order to enable the mariner to secure a bearing) that some light beside the revolving light, particularly if it is a quick revolving light, should be visible throughout the whole revolution at as great a distance as possible.

More red lights recommended.

Red and prominent white lights recommended to be made revolving.

Two separate towers objected to.

Sometimes two lights, even on separate towers, are exhibited, in order to form a distinction from a neighboring light. By this means the expense is very nearly doubled; and where distinction is the only object gained, it appears to show more prodigality than ingenuity.

It is also desirable that a light-house should be a very visible object from the sea by day. Your Commissioners during their visits had frequent occasion to remark how little this had been considered, especially in Scotland, where the handsome stone towers unpainted could often be scarcely distinguished at a distance from the grey background. We recommend that the light-houses should always be colored, so as to present the greatest contrast with the background, and that the buildings and walls attached to the towers should be kept carefully whitewashed where the ground is dark.

The coloring of light-houses with reference to background recommended.

The distinction of light-houses by day is susceptible of much development by the more extended use of colored stripes or bands.

There is another important point connected with the *quality* of light-houses, to which your Commissioners have given attention, namely, the means of indicating the locality during fogs which the light cannot penetrate. This is sought to be effected by bells, and in one or two instances by guns; but it is rarely attempted at stationary light-houses, except at those built on rocks in the sea, or on piles. We recommend the more frequent adoption of whatever means may be found most efficient.

Further use of fog signals recommended.

The signalizing of storms from light-houses recommended.

Your Commissioners consider it desirable that Admiral Fitz Roy's plan of notifying at the principal ports the approach and course of storms should be extended to certain of the light-houses in prominent positions, for the purpose of such information being signalized thence to passing ships; and if the Astronomer Royal's proposition for exhibiting a time-ball at the Start should be carried out, such signals might be advantageously established at that point. Admiral Fitz Roy has supplied various light-houses in the United Kingdom with the necessary meteorological instruments. In several of the answers to your Commissioners' scientific inquires the same suggestion is touched upon. Had such a system existed when the Royal Charter was lost, that fearful wreck might possibly have been avoided.

Quality compared with Foreign Lights.

Quality compared with other countries.

With reference to *the quality of the lights of the United Kingdom as compared with foreign lights*, the answers to questions show that the majority of the mariners who use them consider British lights generally to be at least equal to all others in the world, and that those of France rank next. Out of 586 who have replied to question 4, "Do you think that the coasts of the United Kingdom are as well lighted as any of the foreign coasts which you have already named?" 514 consider the coasts of the United Kingdom as well lighted as any others with which they are acquainted, while, in reply to question 5, "If you think that the coasts of the United Kingdom are not so well lighted as those of any other country or countries, name those countries in the order in which you prefer their lights," out of 311, 200 express their preference of the British lights, and only thirty-three prefer those of any other country. Nor is this due to any patriotic prejudice in favor of England, for of the thirty-four masters of foreign vessels who have answered question 4, twenty-four think England as well lighted as any other country they know; one is doubtful; but not one foreigner prefers the lighting of any foreign shore.

These comparisons by the 200 mariners who prefer British lights and the thirty-three who prefer those of some other country have, however, been more closely analysed; and it appears that out of the 200, only forty-two profess to be well acquainted with the coasts of France, while it must be remembered there are twenty-five who express a preference for the French lighting. This weight of evidence, therefore, in favor of the United Kingdom as compared with France is not great. Many circumstances also must interfere with the accuracy of such comparisons; for instance, on the one hand, an advantage is given to foreign countries by the greater clearness of the atmosphere, and, on the other hand, an advantage is given to Great Britain by its shores being the usual landfall of those mariners who have replied to the questions.

The testimony of the replies given to question 7 of the same circular, "What British and what foreign lights have you usually seen furthest off, and which of the two has been usually visible at the greatest distance?" is to a similar effect; but it refers only to the brightest lights; and an analysis of these replies gives several additional points of interest. Such an analysis is made in the tables in Vol. I, pp. 114–119, and the following are the principal results:

Five hundred and seventy-nine witnesses have mentioned the twenty-five light-houses named in the table as the British lights which they have usually seen farthest off.

These have made 184 direct comparisons with the foreign lights which they have usually seen farthest off.

And in reply to the question which of the two has been usually seen at the greatest distance, 112 witnesses are in favor of British lights, seventy-two witnesses are in favor of foreign lights, giving a majority in favor of British lights of forty on 184 comparisons. Fifteen of the twenty-five British lights mentioned are preferred to the foreign lights compared with them; one is equal, nine are inferior; giving a majority of six in favor of British lights. Of the fifteen British lights preferred, nine are catoptric revolving or flashing, two catoptric fixed; two dioptric fixed, two dioptric revolving.

Nine British lights are said to be inferior to those foreign lights compared with them. Of these British lights, three are dioptric fixed, two dioptric revolving or flashing, two catoptric fixed, two catoptric revolving.

This large preponderance of evidence in favor of the catoptric revolving over the dioptric revolving, as hitherto exhibited in England and Ireland, and which is further confirmed by the table in Vol. I, p. 117, fully confirms the remarks made, and the reason of it and the remedy are there given.

Dioptric revolving lights ought to be very powerful. Of the two which are considered inferior to the foreign lights compared with them, the Start is one, and the condition of that light, which is described by us, will show the value of these comparisons made from observations at sea by the men most interested in the lights. The other inferior dioptric revolving light is Ballycottin. It appears from the reply to question that the annual consumption of oil is 354 gallons, as against the Start 498, the South Foreland 511, Skerry Vore 781, Kinnaird Head 800, while at Grisnez it is stated to be 785, all of which are dioptric, first-class. And this again shows the correctness of the comparisons, for the oil burned is a measure of the light produced.

Again, of all the foreign lights mentioned and compared, Grisnez (probably from its prominent position) is most frequently named. It is mentioned as seen at great distances by 108 witnesses; but of the twelve British lights compared with it, seven are said to be better, five worse; and of forty-eight comparisons between it and British lights, thirty are in favor of the latter.

The above evidence, then, goes to show that the quality of British lights (speaking generally) is equal to the quality of lights in any part or the world; and the testimony is especially valuable, because the men who gave it are mariners, those best able to judgr of the appearance of the light; and, as appears from their evidence elsewhere, generally know nothing about the manner in which the light is produced. As one witness remarks, "they don't know the ropes," C. and D., (catoptric and dioptric,) but most of them think that first-class British lights, speaking generally, are as good as most first-class lights which they have seen abroad, and better than many.

Your Majesty's Commissioners have no reason to differ from this general opinion; but in subscribing to it, we think it necessary to revert again to the various defects that we have ascertained to exist in the present dioptric lights, especially of England and Ireland, and to the experiments, observations, and reports that have been made by us or at our instance on the matter. There are, indeed, many particulars in which the quality of British lights might be greatly improved.

There was a time when the shores of this kingdom were unquestionably much better lighted than those of other countries. At that time silvered parabolic reflectors with Argand lamps were considered the best of optical apparatus for light-houses, and they were largely used and are still retained in very many situations by the general light-house authorities. Amongst local authorities, smoky lamps, candles, and tin reflectors, some even painted in front, may even now be found.

There are indeed many situations in which reflectors properly kept are supposed by the light-house authorities to be as useful as lenses; and the labor, care, and skill bestowed by the keepers on the cleaning of the reflectors assist in making some British catoptric revolving lights compare favorably with the best lens lights in France. In catoptric revolving lights, the number of lamps and reflectors on one face can be multiplied so as to increase the power. Beachy Head, for example, is a catoptric revolving light, showing ten reflectors on one face, and is favorably compared with Grisnez, which is a dioptric flashing light, though Grisnez is some feet higher than Beachy Head. There is but one lamp at Grisnez, burning, according to regulations, 785 gallons; at Beachy Head there are thirty lamps, burning about 1,000 gallons of oil in a year.

Quality compared with other countries.

The fixed catoptric lights of the British Isles are never mentioned by any mariner as having been seen at a great distance, and, indeed, with the exception of the Lizard, their names scarcely occur among the answers. There can be no doubt that they will not bear comparison with revolving lights on the same principle, or with the dioptric lights of France or Scotland. As to the fixed catoptric lights abroad, (there are scarcely any in France,) not one of them seems to be named, except that on Heligoland, which belongs to the Trinity House.

Particulars of comparison.

On comparing the *quality* of British lights with those of foreign countries in the four particulars mentioned above, it may be remarked—

1st. With reference to the source of light, the observations of the Commissioners have placed it beyond doubt that the French have the advantage over the English and Irish, in the height and brilliancy of their flames, owing mainly to their use of the mechanical lamp.

2d. As to the optical apparatus, the dioptric system, invented and first employed in France, has been gradually adopted in our own country, and in Scotland some improvements have been made in it. There is, however, this important difference: In France the new apparatus was adopted throughout the whole light-house service; and in the United States and in Spain, it has been lately exclusively adopted in the great reformation of the light-house system just effected by the governments of those countries; but in the United Kingdom the old reflectors have only been replaced from time to time by the refracting apparatus; and the Board of Trade now lay down the principle, that the expense should only be incurred when the reflectors are worn out. It still remains an open question in some minds whether the change should at once be completed along the whole shores of Britain, and in other minds whether the purely catoptic principle is not better than the purely dioptric, under certain circumstances; but few will doubt that a combination of the two would often be the most efficient, and such combinations exist in all countries, but especially in Scotland. Your Commissioners, indeed, are prepared to recommend a more rapid substitution of these catadioptric arrangements for the simple metallic reflectors now in use at so many situations, and we deem this especially requisite when the light is a fixed one. If the electric light come into general use, it may necessitate some important modifications of the existing apparatus.

Substitution of catadioptric for catoptric apparatus recommended.

3d. As the dioptric apparatus used in England has been obtained from France till very recently, or constructed on French models, it can be no matter of astonishment that your Commissioners found in that country the same errors of adjustment between the optical pieces and the lamp which they had first remarked at home; but these errors were greatly aggravated in England and Ireland, where the flame was low. The excellence of the light at Grisnez was found to be due partly to the height of the flame of the mechanical lamp, but partly also to the fact that the old-fashioned mirrors had been well adjusted to the sea-horizon after erection—a point that cannot be so easily secured in apparatus of more modern construction, (such as is used at Calais,) where the totally reflecting prisms are secured in their places before the apparatus leaves the manufactory, and without reference to the altitude of the proposed situation. There was, however, but very slight fault to be found with the adjustment of the illuminating apparatus at Ailly.

4th. In regard to the distinction of one light from another by varying its character, the French, according to the Admiralty Lists, do not avail themselves so much as the English of the various means, and the Americans seem to be inferior; but in Spain and Brazil the proportion of revolving to fixed lights is much greater, and red flashes are more frequently employed than in the United Kingdom.

The United States authorities pay more attention to the distinction of light-houses by day, by means of color, than the authorities in this country.

The French use silk webs in the wicks; and filter the oil that has flowed through the burners before returning it to the lamp for another night's consumption.

An account of a bell with a reflector, on Boulogne pier, used in foggy weather, with evidence as to the extent to which it answers its purpose, will be found.

EXPENSE OF CONSTRUCTION AND MAINTENANCE.

Expense of construction.

The *expense of constructing* a light-house depends so much on the requisite height of the tower, the accessibility of the site, the facility of procuring material or workmen, and many other circumstances, varying with the locality or the character of the work, that it is difficult to form a comparison between the practice of different boards in this respect; yet there are some points which appear worthy of remark.

The triumphs of light-house engineering are those towers which rise in the midst of an open sea, on small isolated rocks or reefs that are washed over by the waves. The Eddystone was the first of this class, but it has been exceeded in magnitude, and in the difficulties overcome in the construction, by three more recent erections, the heights and total cost of each of which are given below:

Bell Rock, Scotland, east coast—height 117 feet; cost, £61,331 9*s.* 2*d.*
Skerry Vore, Scotland, west coast—height, 158 feet; cost, 83,126 12*s.* 1*d.*
Bishop Rock, England, Scilly Isles—height, 145 feet; cost, 36,559 18*s.* 9*d.*

The two last are, to a certain extent, comparable works, both being erected on rocks almost covered by the sea at high water, both far from land, and exposed to the force of the Atlantic, and both more or less on the model of the Eddystone; yet the Bishop, which is nearly as tall as the Skerry Vore, cost in construction less than half what was expended on that magnificent work. It must be remembered, however, that at Skerry Vore, the workmen, the materials, and all the requisite stores, had to be conveyed a distance five times as great as at Scilly, which in that stormy region rendered the chances of landing much more precarious, and that a quarry and harbor had to be formed; circumstances which involved a large expense that cannot be estimated with any precision.

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The only complaints which the Commissioners have heard respecting the cost of erection of light-houses have been with reference to the Scotch, and have proceeded from the Board of Trade. The structures erected during this century in that country are doubtless most substantially built, generally of granite, and of great height; there seems to be very little outlay on mere ornament, and they present a noble appearance as public works; but when the great difference in cost between them and the English light-houses designed to serve a similar purpose is considered, there can be little doubt either that the Scotch and Irish authorities have not paid due regard to economy, or that the English authorities, keeping economy too closely in view, have not erected edifices worthy of themselves and of the nation; unless, indeed, there be some circumstances which render similar erections necessarily more costly in Scotland and Ireland.

Expense of construction compared with foreign countries.

It is difficult to compare justly the *cost of construction* between the different portions of the United Kingdom; it is still more difficult to draw a comparison with the expense incurred in countries where labor is very differently remunerated, and where the management of light-houses is centralized in the National Government.

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On the whole, therefore, the outlay of foreign governments in the construction of light-houses, making every allowance for the advantages which a more centralized system gives in such a comparison, appears to be rather greater than the outlay incurred by the English Board.

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EXPENSE OF MAINTENANCE.

Expense of maintenance.

The expense of maintenance of a light depends to a great extent on its class. It would be futile to attempt a comparison by taking the whole amount expended on lighting the coasts by each general authority, or by each different country, and dividing that by the number of lights, unless it were ascertained that the different classes were in the same proportion, and that all expenses of light-ships or buoys were excluded.

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Scotch method of consuming oil commended.

From this it is evident at a glance, that as the Scotch dioptric lights burn a larger amount of oil than the English or Irish, they are more expensive in that item; but in this particular, expense becomes a measure of efficiency. The Scotch effect a saving in oil, amounting to about £1,300 per annum, by lighting and extinguishing their lamps not at sunset and sunrise, but at the going away and reappearance of daylight, periods calculated separately, and tabulated according to the latitude of each station. The amount burnt in the large catoptric lights of each country is about the same, oil being 1*d.* or 2*d.* per gallon cheaper in England than in Scotland or Ireland. Repairs of buildings is a larger item in the English than in the other light-houses, as they are usually older constructions, and of a less substantial character. The Scotch towers are generally not painted. As to the total expenditure, there is evidently a discrepancy in the manner in which it has been returned by the different authorities, the Northern Commissioners and the Ballast Board having included items not included by the Trinity House, thus showing a greater discrepancy than exactness would warrant.

Besides the expenditure incurred in the individual light-houses, there are the general expenses of the authority having charge of them. This is an important subject of inquiry, but will be better treated of under the head of "system of management." * * * *

The French Government pays the keepers much less than is paid by any of the general authorities in the United Kingdom, but its outlay in oil is very properly greater than in England or Ireland. The United States, on the contrary, pay as much as £275, in keepers' salaries for a first order light-house, whilst the Trinity House pays on an average £126 10*s.* 9*d.*

FLOATING LIGHTS.

Number. The number of floating lights in position in the United Kingdom is forty-seven.

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The evidence which the Commissioners have obtained from the masters of light-vessels goes to prove that the most exposed situations are not necessarily the most dangerous or disagreeable. The masters of the Seven Stones and Coningbeg light-vessels agreed in saying, that the long sea, and great length of chain required to anchor in deep water, made their stations, which are the most exposed in the kingdom, easier to ride in than stations where the sea is shorter, the water shallower, and the current stronger; such as at Arklow, the Owers, and Cockle; and the master of the light-vessel in the Humber, who had crossed the Atlantic sixty times, said that he had never met with so "nasty" a sea as in the River Humber.

This, which at first sight appears strange, is explained by the fact, that when the wind is strong and its direction across a strong tide, a vessel often rides broadside to the sea. In the open sea the tides are not so strong, and the waves are longer.

The light-vessel at the Goodwin was seen by the Commissioners so riding, to windward of her moorings, broadside to the sea, and rolling heavily.

Quality. The efficiency of a floating light depends on the attention paid to the four points dwelt on in reference to the quality of lights on shore, with one very important addition, namely, that it should remain on its station in all weathers.

The best proof that the lights are efficient in the last particular is to be found in the statements of the light-house authorities, which are fully confirmed by the evidence of mariners. The light-vessels very seldom go adrift, and there is no instance on record in which the crew have voluntarily run from their stations in bad weather. When they have been driven from their moorings, the vessels have always been replaced in a very short time, and none have ever been wrecked. The mariner's evidence on this point is valuable, because the rare instances in which light-vessels have been off their stations are repeatedly mentioned by independent witnesses as remarkable events. It does not appear that the lights have ever been accidentally extinguished.

Form of light-vessel.

Much has to be learned about the best form for resisting the force of winds and waves when the vessel is always at anchor. The shape of the hull now varies considerably. Some are longer than others. The part of the vessel to which the moorings are attached, and the points where the chains enter, are different. The Irish vessels are generally longer and sharper than those in England, and set an after-sail when its use enables them to ride more easily. We have endeavored to obtain evidence on these points, and have received many valuable opinions in reply to our questions on flotation. The testimony of the men on board has been in favor of considerable length, fine entrance, and a low point for attaching the moorings; but we would recommend this branch of scientific inquiry to the attentive consideration of those who have to decide the question practically, as these questions materially affect the steadiness of the light, security of ship, and safety and comfort of the men.

The source of light in light-ships is invariably the combustion of oil. Mechanical or large lamps are not employed.

The apparatus by which the light is directed to where it is needed consists of silvered reflectors and Argand lamps. In three instances only has the dioptric system been adopted in light-ships, one of them being the local floating light of Stockton-on-Tees.

The reflectors are also smaller afloat, and, with one or two exceptions, only one reflector is shown on each face, and can be seen at once. The silver is much more liable to injury, and the reflectors were generally found to be in a less brilliant condition than any that were seen on shore; though in some of the vessels the reflectors were quite as well polished as any seen. Reflectors also wear out much sooner at sea.

Improved illuminating apparatus recommended.

It is a question for consideration whether the dioptric principle might not be more generally introduced into floating lights; and whether some of the improved methods of producing light might not be adopted afloat. The science of illumination, as regards floating lights, requires development, especially as ship's lights are now made so brilliant.

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Red revolving lights recommended.

In regard to the distinction of the light of one light-ship from another, or from shore lights, or from the lights of moving vessels, your Commissioners cannot help thinking that red might be more frequently used, provided the revolving dioptric apparatus is adopted, and that a larger proportion might advantageously be made to revolve, provided the rapidity of revolution be sufficient to prevent the long extinction of the light.

Another point is the color and distinguishing mark of floating lights by day; for it is important to every mariner to be enabled to recognise a particular light-vessel at a glance.

The Trinity House light-vessels are painted red. In Ireland they are black with a white streak. At Liverpool, two are red and one black; and they are all distinguished by balls hoisted at the mastheads, and by other signals, and some have their names painted on their sides. Black and red seem to be the colors which contrast best with the color of the sea, and they are in fact best seen.

Improved fog signals recommended.

Gongs are used as fog-signals in the light-vessels of the Trinity House and Ballast Board; but your Commissioners are satisfied that they are not sufficiently powerful, and recommend the provision of a more efficient warning in fog as a subject of investigation and experiment.

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It is evident that, whether at home or abroad, it is far more costly to maintain a light afloat than on shore, and where the light itself cannot be made perfectly stationary, a refined adjustment of the illuminating apparatus to the horizon would be injurious. Where practicable, therefore, stationary buildings should be erected, such as the screw-pile light-houses at the mouth of the Thames, and elsewhere.

BUOYS.

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Quality

The prime requisites in a buoy are that it should be conspicuous, distinctive, and permanent.

It appears from the returns, however, that buoys are liable to various accidents, especially that of being fouled or run down by ships. Of the 356 Trinity House buoys in position, only 14 broke adrift in 1858; none of the egg-bottomed or flat-bottomed buoys were so displaced in that year. Of the 92 buoys belonging to the Northern Commissioners, 2 only broke adrift in 1858; and of the 53 buoys under the Ballast Board, only the same number; while of the 608 buoys under local authorities, a somewhat larger proportion, namely, 35, broke adrift, though these latter generally ride in much less exposed situations.

Some buoys, for instance those under the Admiralty, in the fairway leading into Portsmouth harbor, disappear under water as soon as the tide becomes strong, and only reappear at slack water. Generally speaking, the buoys in use are not constructed on scientific principles; but there are others, either used or designed, which show more thought. Herbert's buoys have been tried on a large scale at Liverpool, in Ireland, and in England, and appear, when properly constructed, to be excellent. Lenox's, Poulter's, and Peacock's buoys, and many other forms, appear also to ride successfully; and in the Clyde there are large iron buoys of peculiar construction, which are commended.

The best form for a conspicuous floating body, to be permanently anchored at a particular spot, and the best method of securing it, have yet to be decided.

We have also asked and obtained the evidence of scientific men on this point, and would specially recommend the subject to the authorities who have to deal practically with it.

Another and a very important inquiry as to the efficiency of buoyage, is the system on which channels and harbors are buoyed, and whether, indeed, any system is adopted. Till lately, there was no atempt at uniformity in any part of the British Isles, but the Northern Commissioners adopted a system, the main feature of which is placing red buoys on the starboard hand in entering the harbor, and black on the port hand. The Irish Board have frequently adopted a system, too, but it is exactly the reverse of the Scotch; and only last year the Trinity House have decided to buoy channels uniformly, but on a totally different plan, namely, red or black buoys to starboard, and chequered to port, but they do not contemplate applying it to channels already buoyed. The Board of Trade has required that Lough Swilly, in Ireland, should be buoyed on this system. In the meantime, some of the local authoities, as those at Liverpool and the Clyde, have adopted systems of their own, which may or may not be the same as that of the general authority in the same country. The Admiralty have no uniform system.

Uniform system of buoyage recommended with dark colors.

Your Majesty's Commissioners recommend that some national system be introduced into the United Kingdom, and that the colors adopted in it should be dark. In support of this we would again call attention to the mariners' evidence. Of 268 mariners who have replied to question 28, 148 are in favor of a uniform system, and a very large majority of those who have replied to question 17, prefer black and red for colors, and angular forms, as being the most visible on the sea. The disadvantage of white under such circumstances has been frequently illustrated. Attention is directed to various proposed systems of buoyage.

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Expense of construction.

The original cost of a buoy varies greatly with its character and size. The Trinity House generally employ can buoys, costing from £27 to £36, but it has many of a better kind, costing £58, £130, and even £197, when complete. The Ballast Board makes most use of a buoy costing £26, but those costing £42 10*s*., or £62, are not infrequent, and their largest, Herbert's buoy, cost £99 4*s*. The Northern Commissioners, on the other hand, do not employ other than the old nun and can buoys, costing from £16 16*s*. to £31 10*s*.

Expense of maintenance.

The repairs required by a buoy arise mainly from accidents. Painting, however, is a regular expense, costing annually from £2 10*s*. to £5 5*s*. each in Ireland, 6*s*. 6*d*. in Scotland, and the mere expense of the paint in England, as it is done by the crews of the floating lights when off duty.

Cost compared with foreign countries.

The United States Government commonly use nun and can buoys, costing from £40 to £100. The Spanish obtains its buoys from England.

BEACONS.

Number.

It is impossible to determine the number of beacons in the British Isles, for the word itself is somewhat indefinite, particularly in the local returns, where they cannot be rigidly distinguished from other small leading marks.

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Quality.

In rivers and estuaries, in the United Kingdom and elsewhere, beacons are commonly sticks or beams of wood, planted in the mud, or fixed to rocks. Sometimes a beacon is a pile of stones, but there are also beacons of solid masonry, and structures of iron solidly fixed in places where such marks have been thought sufficient, and a light was not thought necessary. There is a beacon on a rock near Stornaway, which

Pile-beacons commended.

reflects light directed upon it from a light-house on shore. Hollow pile-beacons have been erected on some shoals, as on the Goodwin Sands, and might advantageously be substituted in other places for buoys, just as permanent pile light-houses are being in some places substituted for floating lights.

Uniform system of coloring beacons commended.

The beaconage of the United Kingdom, like the buoyage, is on no uniform system of color, or form, or construction; and generally nothing but local knowledge enables a mariner to tell his position by the beacons alone. The navigation of the Clyde is much facilitated by beacons solidly built at short distances from one another, and marked both by color and by other indications, so as to show on which side of them is the channel. What is there effected might be attempted with advantage in other places under other jurisdictions.

Speaking generally, the beaconage of the United Kingdom admits of great improvement. The number might be increased, and the quality improved, and the efficiency of the service advanced.

Expense of construction and maintenance.

The expense of erecting a beacon depends of course wholly on the nature of the construction and of the site. The cost varies from that of the beacon on the Wolf Rock, off the Land's End, amounting to £11,298, to that of "Jack-in-the-Basket," at the entrance of Lymington Creek, a mere pole painted white, with a basket at its top. The Pabba Beacon, in the Sound of Skye, the latest erected in Scotland, is of malleable iron, forty feet in height, and cost £502 5*s.* 2*d.* The expense of maintenance is in many cases nil, and never should be much, unless in situations where the nature of the position is such that damage is frequently being caused by the almost irresistible force of the sea.

Comparison with foreign countries.

The beacons which your Commissioners have seen abroad, and those described in the returns from foreign countries, do not seem to be better than those of the United Kingdom, except in so far as there is a national system.

In France, the beacons and buoys are colored on the same plan, and even patches of rocks on different sides of the channel are (according to the returns) painted black and red.

In Sweden, the trees which are planted in the water, on one side of a channel, have a bunch of branches at the top, and those on the other side are left bare, and the principle of indicating compass bearings of shoals is acted on.

SYSTEM OF GOVERNMENT.

Management and control.

The system of management and control under which lights, buoys, and beacons are constructed and maintained in this kingdom, as laid down by the Merchant Shipping Act, 17 and 18 Vict., c. 104, is as follows:

The several authorities mentioned in the act are: 1st, the Queen in Council; 2d, the Committee of the Privy Council for Trade; 3d, the Trinity House; 4th, the two other general light-house authorities, namely, the Commissioners of Northern Light-houses for Scotland, and the Port of Dublin Corporation, or Ballast Board for Ireland; 5th, local authorities, of which there are about 170.

SYSTEM OF CONTROL.

1st. *The Queen in Council* may transfer to a general light-house authority the powers of a local authority within its jurisdiction, making default in erecting, maintaining, or placing any local light-house, buoy, or beacon. (Sec. 395.)

Queen in Council.

The same power may consent to the following acts by the general light-house authorities: Exemption from dues; alteration of mode of collection; substitution of dues, (Sec. 398;) and may fix dues for new lights, or alter their amount. (Sec. 410.)

So far as your Commissioners are informed, the powers of local authorities have very rarely been transferred from the local authorities who exercise them. One case was the light at Douglas, Isle of Man, lately transferred from the local authority to the Scotch Board. Provision has to be made for dues in such a case. Secs. 395 and 413 seem to give the necessary powers. Under Sec. 397 the Queen in Council may alter dues.

2d. *The Board of Trade* may, on complaint of inefficiency, authorize persons to inspect all light-houses, buoys, and beacons under the general light-house authorities, and may at all times demand from them returns, explanations, &c. (Sec. 393.)

Board of Trade.

From the evidence before your Commissioners, it appears that the first of these powers has been very little exercised, and that the latter has to a very great extent.

The Board of Trade may sanction interference with local authorities by general authorities, (Sec. 394,) but your Commissioners are not informed that they have ever been asked to do so. This section gives large powers to the general authorities, but they have been exercised only to a very small extent, if at all.

On the contrary, it appears from a letter dated 9th February, 1859, that as regards the harbor lights marked in the Admiralty Lists, the Board of Trade had "no information to enable them to state by whom they were then managed;" and it further appears, from the return of the Scotch Board, that the Commissioners for Northern Light-houses could only furnish a list of these local authorities, *so far as known*, and it does not appear from the returns, or from the personal observations of your Commissioners, or from the oral evidence, that local lights are inspected or interfered with to any extent by any of the general authorities.

Your Commissioners have reason to believe that very little *control* of any kind has been exercised over the local authorities, and we generally found the lights to be less efficient than those managed by the general light-house authorities, and to be managed on no regular system of any kind.

The Board of Trade may direct the general authorities to account for and pay over to the Paymaster General the dues collected by them, (Sec. 402,) and this they have accordingly done. There was on February 6, 1860, a very large surplus of £361,645 1*s*. 2*d*., invested in Exchequer bills and cash, in the hands of the Paymaster General.

The Board of Trade may decide questions in dispute between the Trinity House and the other two general light-house authorities, by granting or withholding their sanction, either wholly or partially, and either with or without modification in relation to the matters submitted to them (Sec. 406.) The directions given by the Board of Trade in relation to the matters aforesaid shall forthwith be communicated by the Trinity House to the general authority in question, and that authority is bound to act in conformity therewith. (Sec. 407.) Under Sec. 408, the Board of Trade may sanction directions of the Trinity House to the other two light-house authorities, but we do not find that the Board of Trade are empowered by the act to direct the Trinity House as to their *management;* and we are informed that the Board of Trade, whatever may be the nature and extent of the power which they actually exert, only *claim* "the control of the purse." But the power given to the Board of Trade by Sec. 405, which seems intended only to meet cases in which the Trinity House do not signify their approval of the works which the other general authorities submit to them for their sanction, appears to have been taken to embrace other cases, and to include a power of control over the Trinity House; and such a power of control has been exercised in many instances in England, Ireland, and Scotland.

Under sections 408 and 409, the Board of Trade have power to sanction directions originating with the Trinity House, and addressed to the other general authorities, and they act as a court of appeal; but no case has been brought to the knowledge of your Commissioners in which this power has been exercised.

Illustrations of system of control.

As illustrations of the manner in which the control of the Board of Trade is exercised the following may be cited: In the case of Godrevy, the Trinity House, anticipating the non-concurrence of the Board of Trade, on the score of economy, selected a site, but not the site they would have preferred, and it was finally adopted; but not until after several other sites had been suggested by the Board of Trade, and after a correspondence extending from July 13, 1855, to November 18, 1857.

In the case of the light-house at North Unst, the Commissioners of Northern Light-houses were overruled through the Trinity House, and a temporary light-house was built on a situation of which the engineer of the Scotch Board disapproved. The men considered themselves to be in great danger when the bad weather came on, and they are now, as appears from the correspondence, cut off (in the permanent light-house) from communication with the shore whenever the weather is foggy, because their Lordships would not sanction the laying of an electric telegraph which the Commissioners wished to construct; and the making of a path from the houses to the shore, to facilitate a walk of some miles over rough ground, was refused. The keeper on shore is now compelled to walk over hills, in all weathers, and often in vain, for the signal hung out is frequently invisible from fog, when the observer arrives at the point from which the light-house can be seen in clear weather; and one keeper nearly lost his life in the performance of his duty. The great importance of this signal being made out *every day* is dwelt on by Mr. Cuningham in his evidence.

Again, the light at Holborn Head was made the subject of a voluminous correspondence, lasting from December 24, 1856, to February 9, 1860. The cost of the site was £200. The main questions in dispute—the breadth of a road, and whether the proprietor of the land should be entitled to use it—and the result is thus described in a letter from the proprietor: "The terms * * * are the same proposed by the Commissioners and agreed to by me more than two years ago."

The Ballast Board of Dublin, in 1854, were deprived of a steamer which they purchased in 1851, in consequence of the Board of Trade not considering it sufficiently used. The vessel was transferred to the Trinity House, and sold by order of the Board of Trade; the original cost was £18,500, and the price realized about half that sum; and the Ballast Board forward stores to light-houses in sailing vessels, make their inspections in steamers borrowed from the Trinity House, and shift buoys of large size by means of a small steamer called the "Midge," which your Commissioners saw, and considered to be wholly unfit for the seas of the Western Ocean. In consequence, as it is stated, stores are delayed, so as to endanger in some instances the extinction of lights in distant situations. The members of the Ballast Board are delayed and impeded on their inspections, and their movements being known long beforehand, their visits are expected and are less useful. The buoy service is made one of considerable danger, and it is unquestionable that the money saved is quite insufficient to counterbalance the risk incurred and other disadvantages. In this case the Board of Trade, as appears from the correspondence, not only deprived the Ballast Board of the steamboat, contrary to the wishes of the Ballast Board, but entered into negotiations with steamboat companies for shifting light-vessels.

The Commissioners for Northern Light-houses were overruled in the selection of the illuminating apparatus to be used at the Butt of Lewis, and again at the light-house of Rhu Vaal, at the entrance of the Sound of Islay, as to the height, as to the arc to be illuminated, the color exhibited, and the purpose of the light. The decision was opposed to the opinion of the surveying officer on the district, and to that of the seamen and others acquainted with the locality; and it does not appear that it was wholly approved by the Trinity House.

Illustrations of system of control.

The light-house on the Iron Rock (Sound of Jura) remains unbuilt, in consequence of a difference of opinion as to an estimate (£9,360) for plans which had been approved by the Board of Trade, but which, as they maintained, must be executed, if at all, for a considerable less sum (£6,000) than that which the engineer employed by the Commissioners of Northern Light-houses considered necessary. A voluminous correspondence took place, which has ended in the complete suspension of all proceedings, to the detriment of the service. The Board of Trade, although fully admitting the remarkable accuracy of the estimates of the Messrs. Stevenson, as tested in numerous works by the ultimate expense incurred on them, refused to allow tenders to be invited for this light-house, seeing apparently some connection which your Commissioners have been at a loss to discover between the amount of an engineer's estimate, known only to the authorities, and that of the tenders which follow it.

When a gun was asked for as a fog-signal on board the Kish light-vessel, the Board of Trade objected to the expense, on the ground that it was for the benefit of vessels trading to the port of Dublin, and to the fact of a gun being fired, as it might possibly be mistaken for that at Holyhead by vessels that were not crossing the Irish Channel. Yet at length they consented to a large bell, of peculiar construction, and afterwards allowed the gun instead, provided it was not purchased or maintained at the expense of the mercantile marine fund, and if fired always twice in succession.

And so the power of the purse appears to be construed into the right to control the action of the authorities in all matters, however minute, which involve the slightest expenditure.

The Board of Trade claims to exercise their power of control to this extent under clauses 422 and 406 of the merchant shipping act. It becomes a subject for consideration how far the control so exercised is beneficial or necessary, and whether the saving in cost (if any) secured is worth the time lost, and the danger run by ships during these lengthened discussions between the authorities.

It appears to your Majesty's Commissioners that the better and simpler course would be to make the light-house authority—which ought to be responsible for the position, character, and everything connected with the work—responsible for its cost.

As matters are at present, the Scotch Board and Irish Board cannot be held responsible, for they have two masters over them; and as the Trinity House were practically overruled in the case of Godrevy, the real governing body has come to be the Board of Trade.

Controlling department considered.

It is therefore important to consider whether the Board of Trade, when acting in strict accordance with the provisions of the act, is the department of government best constituted to form an opinion on subjects connected with coast illumination, and better able to judge of the necessity of establishng new works than the authorities who propose them. For example, Captain Bedford, the surveying officer on the west coast of Scotland, proposed the placing of certain buoys which he considered to be of importance for the interests of general navigation; the Commissioners for Northern Light-houses approved of most of these suggestions, adopted some of them, and, on the 8th of March, 1860, wrote for the statutory sanction of the Trinity House for the placing of these buoys. On the 21st of March, the Elder Brethren "did not feel that they would be justified in recommending to the Board of Trade that they (the buoys) should be placed at the expense of the mercantile marine fund." And, on the 9th of April, the Scotch Commissioners appealed to the Board of Trade, on the ground that the reasons given by the Elder Brethern were insufficient. They pointed out that some of the buoys were intended for the use of vessels navigating the Caledonian Canal, and others for those navigating the Sound of Jura, where it has been thought advisable to erect two large light-houses for general purposes, and that other buoys were for other localities where beacons and light-houses are in course of erection as part of the general scheme.

On the 20th of April, the Board of Trade sanctioned the placing of *one* of the proposed buoys, but it was stated that, "as regards the other buoys, my Lords, without entering into the question whether they would be useful for the local, rather than the general trade, are not disposed to think them necessary, and must, therefore, decline to sanction the expense."

Assuming that this decision is strictly within the provisions of the act, and setting aside the rights of the question, your Commissioners deem it to be a matter for grave consideration whether the constitution of the Board of Trade is such as to make that department of the government best able to judge of such questions. The surveying officer on the station, who has the best opportunity of judging of the facts, and the Commissioners, who are responsible for the work, are agreed. The Trinity House differ from both on a financial question; and the Board of Trade differ from all, and decide on a question of expediency. They sanction the placing of one buoy, admitting the principle for which the Scotch Board contend, and so overrule the Trinity House; they refuse to sanction the rest, and so overrule the Scotch Board; and they give as their reason that they do not consider those buoys necessary.

In this recent case, then, the principle of government is clearly laid down. and brought into action. The refusal is on the ground of expediency; the question in dispute is not settled, but the umpire decides the matter from his own point of view, and so far as regards the Scotch and Irish Boards (if not the Trinity House itself) the principle of this case seems to be the ruling principle of the control as at present exercised by the Board of Trade over the light-house authorities.

If this is the principle authorized by the merchant shipping act, the independent action of the light-house authorities has ceased to exist. The governing authority has, in fact, become vested in the Board of Trade, though no provision is made by the act to enable that department to judge more accurately of such matters than the light-house authorities, who are controlled, and the Admiralty surveying officers, whose local knowledge has been disregarded. If the governing power is really vested in the Board of Trade, and if that department is so constituted as to be competent to conduct the service, the other authorities are superfluous. On the other hand, if the general authoritis are necessary, and conduct their business satisfactorily, and are to be continued, their powers should not be thus limited or thus controlled.

Present system objectionable.

As matters now stand, the whole management of the light-house service appears to be impeded by the opposing action of three separate governing bodies; and it does not clearly appear what advantage is gained to counterbalance the delay which results from this complicated system.

Controlling powers of Trinity House.

3d. *Trinity House.* The next in order of the authorities having charge of lights, &c., is the Trinity House.

By section 392 of the merchant shipping act, that body may enter and *inspect* all light-houses under the management and control of the two general authorities next in order, namely: The Commissioners of Northern Light-houses, and the Ballast Board, Dublin.

By section 405, it may *control* these two bodies, by refusing its sanction to new works, or to proposed alterations in existing works; but this power is subject to an appeal to the Board of Trade.

By section 408 it may direct the other two to execute new works, or to modify or remove works in existence, &c.; but this power requires the sanction of the Board of Trade, and seems never to have been exercised.

As to the power of *inspection* over the other two bodies under section 392, the Elder Brethren, in reply to question 8, have furnished a return showing the special services and inspections in which they were engaged in 1857 and 1858, from which it appears, that from May 6 to 26, 1857, "a committee (accompanied by Captain Sulivan, of the Board of Trade,) visited the west of Ireland" and "around Scotland," and that they were accompanied by officers of the Scotch and Irish Boards. The names of the places visited are given in detail, and include places on which light-houses have been erected, or on which it has been proposed to erect such works; places which have been the subject of much correspondence, in which the views of the Commissioners of Northern Light-houses differed from those of the Trinity House, and the Board of Trade; for example, the Iron Rock, in the Sound of Jura; McArthur's Head, the Black Rocks, and Rhu Vaal, in the Sound of Islay. The lights visited were few, and the time short, and it was partly occupied in inspecting localities in England, coaling, &c.

On the 17th of May, 1858, a committee of the Elder Brethren visited St. Abb's Head, accompanied by Captain Sulivan, three of the Northern Commissioners, and Mr. Stevenson.

This power of *inspecting* works not in England was, therefore, not exercised to a great extent in these two years by the Trinity House, either in Scotland or Ireland.

As to the power of *control* under sections 405 and 408, the cases in which the Scotch and Irish general authorities have been *controlled* by the Trinity House will be found in the Scotch and Irish replies to question 17, General Light-house Return; question 19, General Floating Light Return and General Remarks, Circular II; and question 18, Buoys and Beacons, Circular V; and in the evidence of Messrs. Cuningham and Stevenson, Sir James Dombrain, and the Earl of Meath.

* * * * * * *

The action of the Trinity House throughout, as appears from that correspondence, has been subordinate to the action of the Board of Trade, and views apparently originating with the Board of Trade have been carried out in cases where a difference of opinion had arisen between the light-house authorities on other points.

It seems, therefore, from these returns, that the power of *inspection* conferred on the Trinity House has been sparingly exercised, and that the power of *control* and direction has generally served to transfer the decision from the Commissioners of Northern Light-houses and the Ballast Board through the Trinity House to the Board of Trade.

SYSTEM OF MANAGEMENT.

System of management.

The *management* of the light-houses, floating lights, buoys, and beacons on the coast of the United Kingdom has been entrusted to what are termed the three *General Authorities*. They are the following:

General Authorities.

1st. *The Trinity House*, by the mercantile shipping act, under section 389, has the *superintendence and management* of all light-houses, floating lights, buoys, and beacons in England, Wales, the Channel Islands, Gibraltar, and Heligoland, except those which are under local authorities.

2d. *The Commissioners of Northern Light-houses*, subject in some matters to the *control* of the Trinity House and the *ultimate control* of the Board of Trade, have in Scotland, and in the Isle of Man, the *management* of light buoys, and beacons, except those which are under local authorities.

3d. *The Ballast Board of Dublin* have similar authority, subject to similar control and exceptions, in Ireland.

Under section 396 of the above act, these general authorities may levy the same dues as formerly.

Under 398, they may, with consent of the Queen in Council, exempt from dues, alter the mode of collection, or substitute dues for other dues.

Under 401, they may, by their collectors, distrain for dues.

Under 402, they account, as is directed by the Board of Trade, and pay over the money to the Postmaster General.

Under 404, they may build, remove, or alter light-houses, and place, erect, remove, or alter buoys and beacons, but the Scotch and Irish Boards must have the sanction of the Trinity House, and, in case of dispute, of the Board of Trade.

Under 415, they may prevent false lights, under a penalty of £100.

Under 394, with sanction of the Board of Trade, they may compel local authorities within their several jurisdictions to lay down new buoys, remove or discontinue light-houses and beacons, and vary the character of light-houses and lights.

And they may prevent the construction of new lights by these authorities.

Under 395 they may apply to the Queen in Council for the punishment of the defaulting local authority.

The powers, then, of these three general authorities are twofold—1st, the power under which they manage their own service; 2d, their control over local authorities.

Before considering the action of these general authorities, it may be useful to give a short account of the origin and history of each.

GENERAL AUTHORITIES.

Trinity House

1st. *The Trinity House.* As appears from the report of the select committee on the foreign trade of the country, 1822, the germ of the corporation existed as early as the reign of Henry the Seventh, as an association for piloting ships.

In the reign of King Henry the Eighth the society was incorporated by royal charter, (May 20, 1514,) and this charter was confirmed and altered by Edward the Sixth, Queen Mary, Elizabeth, and James the First.

The charter of James the First settled this constitution of the corporation, and such it continues.

The charter was dissolved in 1647, but was renewed by Charles the Second, on the Restoration, and the disposal of the funds was settled partly for charitable purposes.

The charter was surrendered to Charles the Second, and renewed by his successor in 1685; and the charitable uses of the funds of the corporation were again settled. These funds were derived from various charges, such as pilotage, lastage, loadmanage, ballastage, &c.

General Authorities, Trinity House.

The light dues, the principal source of the revenues of the corporation in 1822, and the source from which lights are now supported, were chiefly collected under patents granted by the Crown, upon the petition of persons offering to pay certain sums for the erection of lights; which dues the Crown authorized the corporation to receive as a compensation for the erection and maintenance of the lights required.

The corporation had also the power of erecting and maintaining beacons and marks of the sea.

The first light under the management of the Trinity House was erected in 1680, subsequent to the erection of several light-houses by private individuals; and these private persons, and their successors, and others, subsequently erected lights, obtained patents, and under them levied dues on passing ships, which, as trade increased, grew to be large incomes.

Parliamentary Committees, 1822. The following was the state of affairs when the Parliamentary Committee was appointed, in 1822: The Trinity House and private individuals were maintaining lights and levying dues on passing ships, British and foreign; the former applying their funds, amongst other purposes, to support charitable institutions, and the latter applying the surplus of the dues levied to their own uses as their own private property.

With this disposal of the funds, the committee of 1822 found no fault, but they recommended the substitution of a tonnage rate for passing tolls, and the purchase of the interests of individuals in private and leased lights, and that all these should be brought under one control.

1834. In 1834 another parliamentary committee was appointed, which reported on the then state of affairs.

They dwelt strongly on the importance of the service, the impropriety of levying dues on shipping for the benefit of individuals, and on the different constitution of the boards of management in the United Kingdom; and they recommended that all public general lights should be placed under one board, resident in London, and conducted under one system of management.

That the Trinity House should have the management of all general public lights in the kingdom; and that their rules should be altered and extended so as to admit officers of the royal navy and other scientific persons.

The committee considered that the admission of the Hydrographer of the Admiralty, and of other scientific persons, would give a strong impulse towards the execution of the duties assigned to the Elder Brethren; and they mentioned, though they did not recommend, the board suggested by Captain Drummond, namely, a board to consist of four persons.

1, A seaman, (the Hydrographer to the Admiralty;) 2, a scientific chemist; 3, a member of the Royal Society, (an optician;) and, 4, the President or Vice-president of the Board of Trade, together with secretary and proper officers.

They recommended that the central board, when appointed, should examine every local light on the coast. They considered the relative advantages of the dioptric and catoptric systems, and of the oxyhydrogen light, which was suggested as applicable to light-houses. They held that every necessary expense should be incurred for the maintenance of the best light-houses and floating-light establishments which the state of science could afford; and that the light dues should in every case be reduced to the smallest sums requisite to maintain existing and to construct new establishments.

The reports of these two committees are valuable, and contain much information; but it seems superfluous now to dwell on such of the evils as have been remedied; to refer further to private light-houses, which no longer exist, and to the levy of light dues for, amongst other purposes, the support of "poor mariners," a charity which is gradually being abolished. But as the portion of the merchant shipping act which relates to light-houses appears to be the result of the third parliamentary committee appointed in 1845, to consider the light-house question, it is necessary to notice that report also.

1854.

It refers to that state of the law which existed in 1836, but which was subsequently altered in 1854 by the merchant shipping act.

To the financial affairs of the Trinity House, and to their vested rights, which are also provided for in the same act.

It states that the lights in the United Kingdom were then in an efficient state.

That complaints were made of the amount of dues, not of the efficiency of the lights.

It recommends that there should be one central authority, namely, the Trinity House, of which body one-third should be nominated by the Crown.

That light-houses should be maintained at public expense.

That the Trinity House should be repaid the sums spent by them in the purchase of private lights, and failing the adoption of that recommendation, the committee point to the substitution of a tonnage rate for passing tolls.

Trinity House.

The Trinity House is, therefore, a very ancient corporation, which has grown up and has to a certain extent altered with the times, but which is in the main the same corporate body which existed in the time of James the First, if not in the reign of Henry the Seventh.

Its present constitution is explained in detail in the replies to Circular I. It consists of the master, deputy master, elder, and younger brethren. The Elder Brethren are divided into honorary members and acting members. The master and the honorary members receive no remuneration. The acting members are retired masters of the merchant service, except three, who are naval officers. They are recruited from the Younger Brethren, the majority of whom are masters and mates in the merchant sea service, a few are naval officers, and the corporation is a self-electing body.

His Royal Highness the Prince Consort is the present master.

Northern Commissioners.

2d. *The Commissioners for Northern Light-houses* were incorporated by the 38th Geo. III, c. 58., and their present constitution is given in their replies to Circular I.

They consist of two law officers of the Crown, the sheriffs of certain maritime counties, the provosts of certain royal burghs, and the provost of Greenock, and were specially established in 1786, by act of Parliament, for the management exclusively of lights, &c., in that country.

The commissioners are unpaid, and hold their position ex-officio.

The committees which recommended the constitution of a single Central Light-house Board necessarily implied the abolition of this separate jurisdiction, but no complaint was made as to its efficiency.

Ballast Board.

3d. The present constitution of *The Ballast Board of Dublin* is given in detail in their replies to Circular I.

It consists of members of the Port of Dublin Corporation, who at present are mainly connected with the commerce of the Irish capital, but includes a retired naval officer, who previously commanded the coast guard in Ireland.

The corporation acts under the 23d Geo. III, c. 19; and the lights were formerly under the superintendence of various other bodies, such as the Barrack Board and the Commissioners of Customs.

Existing light-house government.

The government of public general lights in the United Kingdom is therefore entrusted to four bodies, differently constituted.

1st. The Board of Trade, a department of the government, whose president changes with the government, whose members are not selected for their knowledge of the science of light-house illumination, and who have not necessarily any officers specially instructed in that subject.

2d. The Trinity House, an ancient corporation, with a variety of duties, many of which are not connected with lights, &c., whose acting members are retired commanders in the merchant service and naval officers; who have a paid engineer, but who have no paid officer attached to their body specially instructed in science, though they are allowed to consult with scientific men, and do consult Professor Faraday from time to time.

3d. The Commissioners of Northern Light-houses, a body consisting chiefly of gentlemen of the legal profession, who have no paid officer for the scientific department.

4th. The Ballast Board, a body whose acting members are merchants, bank directors and governors, magistrates, railway directors, &c., including a retired naval officer.

In short, the government of light-houses in the United Kingdom, their management and construction, are all confided to bodies of gentlemen of various employments, none of which necessarily afford them an opportunity of acquiring a knowledge of those branches of science which bear upon light-house illumination.

Foreign countries.

It is both interesting and instructive to compare the constitution of these authorities with that of the light-house boards in other countries.

France.

In France, the light-house service is under the Ministry of Public Works, and a special commission called "Commission des Phares," which body consists of naval officers, marine engineers, hydrographers, members of scientific bodies, and other gentlemen, distinguished for their scientific attainments, in various professions, all of which have to do with branches of science connected with coast illumination. The general conduct of the service is under an officer called Directeur General des Phares, who is an engineer, and has other engineers under him; and in every district on the coast there are resident engineers employed about government works, and, amongst others, in the superintendence and construction and management of light-houses. The commission have special workshops in Paris for testing and setting up illuminating apparatus, and they give directions to the manufacturers for every part of the light-house apparatus, including the calculation of angles for prisms and curves for lenses, and similar important matters, for which no provision is made in the English system of government.

America.

In the United States of America the lights are under one central board, constituted in 1852, and composed of a member of the government, engineer officers, and officers of the army and navy, and civilians of high scientific attainments.

Sweden.

In Sweden the lights are under the Admiralty, and managed by a director and officers who have military rank, and engineers; and the coasts are divided into districts, and sub-districts allotted to these officers.

Norway.

In Norway the service is under the Royal Marine Department, with a director and assistants.

Turkey.

In Turkey it is under the Admiralty; but the department was at a loss to furnish information.

Hanover.

In Hanover the service is under the Director General of Waterworks. The buoys are placed by pilots; and the lights and buoys are inspected by inspectors of waterworks.

Hamburg.

In Hamburg they are under the Committee for Harbors and Navigation, under the direction of the Commander and Inspector of Pilots.

Spain.

In Spain the system of administration is the same as in France. The lights, &c., are under the Department of Public Works, and under a permanent commission, composed of engineers of superior rank of the corps of roads, &c., and naval officers; and the captains of ports are instructed to suggest improvements and report on the lights.

Denmark.

In Denmark the service is under the Ministry of Marine, entrusted to one light engineer and two buoy inspectors, furnished with instructions relative to their respective official duties.

Russia.

In Russia the superintendence is dependent from the Hydrographical Department.

Holland.

In Holland the management of lights, buoys, and beacons rests with the Minister for Marine, under whom are an inspector general and seven inspectors.

Belgium.

In Belgium the construction of light-houses is under the Minister of Public Works, but when built they are handed over to the general direction of the navy, which is under the Minister for Foreign Affairs. They, with the floating lights and buoys, are under the superintendence of the Inspectors of Pilotage.

Austria.

In Austria the superintendance of all the light-houses, buoys, and beacons belongs to the Imperial Royal Admiralty. The Deputies of the Exchange at Trieste attend to light-houses, their erection, management, collection of dues, &c. The inferiors of the Admiralty attend to the superintendence of buoys and beacons.

Principle of government abroad.

The principle, then, in all foreign countries seems to be, that light-house illumination, being highly important, and requiring special knowledge of certain subjects, should be entrusted to persons acquainted with those subjects, and that the government should be centralized.

Practice in Great Britain.

Whilst the practice of Great Britain seems to have been to entrust light-house illumination to persons whose pursuits did not indicate any previous knowledge of the subject, and the fact that for 404 light-houses, and numerous buoys and beacons, there are at least 174 different authorities, under as many acts of Parliament, shows that the principle of local and independant self-government has at all events not been lost sight of. The Elder Brethren of the Trinity House, however, having been mariners, may be supposed to have had much experience of the practical wants of sailors, and to be peculiarly well versed in all that relates to light-ships; while the Commissioners of Northern Lights, being gentlemen of the legal profession, whose position is a guarantee for their intelligence, may be supposed able to form a good opinion of the character and qualifications of candidates for the posts of secretary and engineer, and to exercise a wise discretion in selecting them, and to collect and form a correct judgment on evidence and matters of opinion relative to matters under their charge; and the Ballast Board, being constituted of gentlemen engaged in large commercial transactions, may be supposed to be well acquainted with general business, and fairly competent to form a correct opinion on such questions as the purchase of sites, and the tenders for the erection of new works, or the materials required for the maintenance of the service.

The light-house boards of foreign countries generally include engineers, hydrographers, and professional scientific men.

The general authorities in the United Kingdom have employed engineers, and that these have been able men is testified by the works which they have erected. The engineer of the Commissioners for Northern Light-houses used to attend the board meetings until January, 1855, when, by the requirement of the Board of Trade, he ceased to do so, to the great regret of the Scotch Commissioners, who were thereby, as they stated, deprived of the presence of the only scientific menber of their board.

Hydrographic aid by Admiralty.

The Hydrographic Department of the Admiralty has frequently lent its service to the general light-house authorities, but they, of course, have had no claim upon that department.

The Trinity House has consulted Professor Faraday as its scientific adviser since 1836, but it appears that he only gives his opinion or advice on such subjects as are submitted to him. The Northern Commissioners have had the great advantage of having associated with them the family of the Stevensons, who have given much attention to those departments of science which relate to light-house illuminatian.

Scientific element wanting.

That the scientific element was very deficient in the system of light-house management in 1834 was evident to the Parliamentary Committee which sat in that year.

That the scientific element continues to be deficient has been evident to your Commissioners from an early period of their inquiry. Many of the preceding observations have indicated this, but, in addition, they would draw attention to the following facts:

1st. The present arrangements often betray an evident want of scientific thought. No greater proof of this can be given than what is contained in the paper on the Whitby Lights, together with the admirable reports of the Astronomer Royal, Professor Faraday, Mr. J. Chance, and Messrs. Stevenson.

2d. The Trinity House, by having secured the services of Mr. Faraday, are fortunately prevented from ever finally committing themselves to the adoption of any impracticable scheme; but by their not having constantly present at their board any scientific person, the carrying out of any invention may be seriously embarrassed, and some invaluable inventions may not be appreciated and thereby lost.

3d. There are a great number of questions of a scientific character, having reference to lighting or buoying the coast, which are as yet unsolved, and only require the attentive consideration of men of science accustomed to experimental investigation, to educe such results as will doubtless increase the efficiency of the systems now in use, and may lead to some extensive improvements. To some of these questions we have incidentally paid attention; and one of our number has drawn out a list of seventy-six separate investigations, which might be undertaken with a likelihood of profitable results.

4th. There is a large amount of scientific talent in the country which might easily be turned in the direction of the suggested inquiries. In corroboration of this opinion, your Commissioners would draw attention to the great mass of valuable information and suggestion which has been elicited from those scientific men—some of them of the greatest eminence—who have replied to Circular IX. These replies are commended to the most careful consideration of whatever authority may in future have the charge of the lighting and buoyage of our coasts.

5th. As a test of the degree of scientific knowledge exhibited by the different light-house authorities, your Commissioners asked for copies of the plans, specifications, &c., actually submitted to the manufacturers in ordering the last two sets of lenticular apparatus of large size or peculiar form. The resulting correspondence is given, with an account of the different practice of the four principal light-house authorities, viz., the Board of Trade, the English, Scotch, and Irish Boards. From this it appears that, in Ireland, forms of tender are issued, "setting forth the arc intended to be illuminated, the number of panels and zones required, and that the apparatus shall be of the best quality, and fitted together correctly;" in England, printed forms and lithographed drawings of small size are furnished to the contractors; while in Scotland, large working drawings and minute directions are given by the engineers employed by the governing authority for the execution of apparatus specially designed by them for special localities.

In case of the English and Irish Boards, the governing body does not originate the design. In Scotland, a design is furnished by the governing body, and the manufacturer has only to execute the order given.

The latter arrangement seems calculated to produce an advance in science; the former is simply an order for a well-known instrument, accompanied, in England, by drawings, which closely resemble those published by the manufacturers in their trade lists, and which are almost, if not quite, identical with the drawings in the trade lists of Mr. Wilkins, a gentleman who does not himself manufacture the glass of dioptric apparatus.

Here, then, seems to be a defect in the system of management. None of the light-house authorities have by their constitution any special knowledge of those branches of science which relate to the construction of the light-house apparatus which they require. When they employ men who have made these particular branches of knowledge their study the result is good. The Commissioners of Northern Light-houses have in this respect shown themselves considerably in advance of the Elder Brethren of the Trinity House, by employing an engineer who has studied light-house illumination, and claims to have invented or introduced many improvements into optical apparatus, to prepare specifications for scientific work. The result of the opposite course, adopted by the Trinity House, is shown in the defects observed at Godrevy, the Start, the North and South Foreland, Whitby, &c.

System of management and control in regard to efficiency.

The inquiry, "whether the present system of *management* and *control* under which the light-houses, floating-lights, buoys, and beacons on the coasts of the United Kingdom are constructed and maintained, according to the provisions of the 'merchant shipping act,' 1854, is well adapted for securing the most efficient lighting and buoying of the coasts," has been to a certain extent practically answered in preceding sections of this report. The different authorities, whether general or local, differ widely in the plans of proceeding; and there is no power given in the act over the internal arrangements of these separate bodies, much less is there any means of insuring uniformity of system. Thus each authority carries on its work in its own way, with a greater or smaller regard to uniformity of action, throughout its own jurisdiction, but with little, if any, regard to the system adopted in other parts of the United Kingdom.

In France the whole is arranged systematically. Lights are placed on a system—that their lights should cross. They are inspected on system—the size of the flame, the quantity of oil to be consumed in an hour to produce a good light, the minutest detail is provided for and calculated to a nicety—and the whole system hangs together, and is under one man. It is a system eminently calculated to produce uniformity and a good result, and it has produced excellent results in a comparatively short time.

It is the Scotch Board that most nearly resembles the French Commission des Phares in its way of managing lights, buoys, and beacons. There is this in common: They have, in the localities where the lights are situated, men of repute and of capacity; in France the Ingenieurs des Ponts et Chaussees, always resident, and in Scotland the sheriffs of the maritime counties, occasionally present; and the members of the two commissions are ex-officio intelligent men, and the actual working of the service is carried on by a small staff, and by men whose business it is, and has long been, to deal with light-houses, and all concerning them, and whose ideas, when carried out, are carried out to the full extent, and in all light-houses alike.

Uniformity desired.

Generally, to inspect the minor arrangements of one light-house in Scotland is equivalent to having seen them all, for the only variety seems to be in the illuminating apparatus, which in very many instances is specially designed for the locality, and has to be separately examined before it can be fully understood; while in England the uniformity is rather to be found in the illuminating apparatus than the minor details of the service, which vary in different light-houses. In Ireland, not only is there a great want of uniformity as to the minor details, but they seem to be very much overlooked and neglected, while the apparatus is about equal to that of the Trinity House.

There are some interesting points of comparison between the plans adopted by the different boards, which have not hitherto been adverted to, and which bear upon the *efficiency* of the service.

The light-houses under the management of the Trinity House, almost without exception, were found to be remarkable for their order and cleanliness. The Scotch light-houses are fully equal to the English in these particulars. The Irish were found to be inferior. In their houses, in the light-rooms, and in other places where discipline, order, and cleanliness should prevail, the Irish lights do not rank so high, though many of them were as well kept in all respects as any visited by your Commissioners.

Details of management compared.

In all the English and Scotch light-houses the men are comfortably lodged. They are provided with books, which is a vast boon to men who pass so much of their time in solitude; and in Scotland this is felt to be so important that certain amusing periodicals are taken in by the board for the use of the men. In Ireland the supply of books is small, and they are rarely changed. In France there are none. Periodical religious services are strictly enjoined in the English and Scotch light-houses and floating lights. In Ireland, owing chiefly to the differences of religious creed commonly existing in that country, this important point is not so easily arranged, and there are no services.

In England and Scotland medicine chests are previded in every light-house and light-ship. In Ireland, as is in France, there are none.

In English and Scotch rock stations, much attention seems to have been paid to securing a proper supply of good water. In some of the Irish rock stations it was found to be otherwise, and filters are sometimes greatly wanted.

The Scotch light-houses are supplied with clocks and sun-dials in good working order. The English light-houses are also supplied with clocks, but only occasionally with sun-dials. The Irish light-houses are occasionally supplied with dials, sometimes with clocks. In many instances the clocks were not going; in one the keeper was dependent for his time on the punctuality of a railway train, which in clear weather was seen to pass on the neighboring coast.

The English and Scotch light-houses have meteorological instruments, but the Irish are ill supplied with such instruments, and generally have none at all.

All the English light-houses have external lightning conductors. There are eleven of the Scotch which are not so provided. The Irish, with the exception of six, are protected by the iron hand-rail from lantern to base, which forms a conductor.

System in Scotland.

In Scotland, as in France, a drawing of the flame as it ought to be when at its best is framed and glazed, and hangs in every light-room. This is not to be found in England or Ireland.

In Scotland, alone, a table of the time for lighting and extinguishing is hung up in the light-room. These times differ for every latitude, and are carefully calculated for each light-house in Scotland, and the result is, as before stated, a considerable economy.

In Scotland whistles are placed in every lantern, which communicate with the rooms below by tubes, in order to summon assistance, if required, and to avoid the necessity of the keeper in charge leaving his post until relieved. There are no communicating whistles in England or Ireland, or in France.

The Scotch lights are inspected at least once a year by the secretary or by the superintendent of light-keepers, or by the foreman of light-house repairs, officers that do not exist in the Trinity House or Ballast Board. The English lights are frequently inspected by a deputation of the Elder Brethren; but many of the Irish lights on isolated rocks are left unvisited for two or three years, on account of the difficulty of reaching them in bad weather in the "Argus," an inferior vessel belonging to the Trinity House, which is lent at considerable inconvenience for the occasion. The "Midge," the only vessel belonging to the Irish board, is quite unsuited for the purpose of inspection.

In Scotland the keepers go through a regular course of instruction and training as extra keepers at light-house stations where dioptric and catoptric apparatus exist, and have to pass an examination before they are entrusted with the care of a light. In England a preliminary course of instruction is gone through at the Trinity Board's establishment at Blackwall; and in Ireland there is no such system of instruction, certain questions only being put to the candidate on his presenting himself. In Spain a practical school for light-keepers is referred to in the Spanish report of 1858; and the school includes instructions in all that concerns the light-house service, practically and theoretically in all the duties that light-keepers may be called upon to perform. In France, the keepers informed your Commissioners that they had been carefully instructed in all that pertains to the machinery of the lamp, and that they had been required to take it to pieces, and set it up again, before they were entrusted with the care of a light. They showed their manner of levelling the burner and adjusting the lamp in the apparatus.

Comparative merits of different boards.

All these points influence the *efficiency* of the lights, and there can be no doubt that, of all the British light-houses visited by your Commissioners, the Scotch are in the best state of general efficiency, the English next, and the Irish third; and the local authorities, with certain exceptions, range far below the general authorities.

As regards floating lights, the Irish excel in some particulars, such as size and form of vessels. The Trinity House light-vessels are, in these respects, inferior to them. From the nature of the English coasts, they are more numerous, and they, as well as the Irish light-vessels, are models of order, of cleanliness, and of well-found ships. The Northern Commissioners have no floating lights.

As regards the number of buoys, there is no comparison. The Trinity House, as in the case of floating lights, have by far the greatest number to meet the requirements of the coast, viz: 356 in position, whilst the Northern Commissioners have 92, and the Ballast Board only 53. The buoys under the Trinity House are generally efficient and well maintained, and in many instances excellent, but hitherto they have been arranged on no general system. Those under the Ballast Board are also good in quality, and generally well managed, and they are arranged according to a system, and the colors used are black and red. Those under the Northern Commissioners are red and black, and also arranged on a system, which is the same as that in France; but they are inferior to the English and Irish in size and quality.

Were there a central light-house board for the whole kingdom, with resident representatives for Scotland and Ireland, it would naturally be its duty to carry out along the whole of the British coasts those plans of any of the existing authorities which had proved most efficient.

System of management and control with regard to economy.

The inquiry whether the "present system of management and control under which the light-houses, floating-lights, buoys, and beacons of the United Kingdom are constructed and maintained, according to the provisions of the 'merchant shipping act, 1854,' is well adapted for securing" its ends, "with a due regard to economy," divides itself into two parts. There is the expense of management incurred by the different authorities, and there are the expenses arising from the complicated system of control.

1st. It is very difficult to compare the *expense of management* by the three general light-house authorities, partly on account of the different manner in which the respective boards conduct their business, and partly on account of the different character of their respective works.

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Expense of system of control.

2d. The present complicated system of government, and reference to superior boards, involves, of course, a certain expenditure in clerical assistance, &c., but this would not be worth considering if the present system really conduces to true economy in the administration of the service. The Board of Trade has steadily kept economy rather than progress in view, but the saving they have thus effected has been represented as sometimes a false economy, and it has unquestionably led to much unsatisfactory correspondence, and in some instances to prejudicial delay. Neither has the control of the superior over the inferior boards been always attended with a saving. Thus, in the case of the Whalsey Skerries, (Shetland,) the Northern Commissioners were directed by the Trinity House and the Board of Trade to build the light on the outer rock instead of the site 700 yards within it, as they proposed. This entailed an additional expense of £10,000 in construction, and involves an additional annual expenditure for maintenance. Yet the Northern Commissioners are still of opinion that the original site proposed by them was the preferable one for a large guiding light, such as that at the Whalsey Skerries was merely intended by them to be.

LOCAL AUTHORITIES.

Supervision or control of local authorities.

It has already been shown that the lights, buoys, and beacons, under the jurisdiction of local authorities are, as a rule, and with some praiseworthy exceptions, inferior to those under the jurisdiction of the general authorities.

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The following cases are some of those taken respectively from England, the Channel Islands, Wales, Scotland, and Ireland.

Examples of management.

The harbor lights at Dover, Folkestone, and Newhaven, on the English side of the channel, present a singular variety of faults, comprising, among them, nearly all those which can be committed in light-house arrangements. Thus, at each of these three much frequented ports, there is a very inefficient illumination, while the travellers leaving them and crossing the channel to Calais, Boulogne, or Dieppe, come at once to small but brilliant harbor lights, which are all dioptric, and in the construction and management of which there are displayed all the achievements of the science of illumination which have yet been imported into the French national system—a contrast by no means creditable to our country.

The Harbor Commissioners at Jersey derive a very large revenue from the shipping that enter the port of St. Heliers. They fully recognize the liability of this revenue to light and buoy the approaches to the harbor properly. This is very inefficiently done, especially as regards the buoyage. The owners of the shipping are very discontented. The

Harbor Commissioners, after extensive correspondence, have failed to give some important information required; but the following fact has been elicited by one of our number, who was deputed to visit the island for the special purpose, namely, that a large sum, £15,000, the accumulation of harbor dues for some years past, had been appropriated to island purposes, which had no connection with the interests of the shipping.

Numerous wrecks took place in the neighborhood of Aberystwith on the night of 25th October, 1859, whereby many lives were lost; and it appears that the losses were attributable to the harbor master not seeing that the pier and guide lights were put up, but going to bed instead.

The contrast between the works of the Northern Commissioners and those of local authorities in the same country is well illustrated at Aberdeen and Peterhead. In the neighborhood of each of these towns is one of the finest coast lights in existence; but at each the harbor lights are ill kept, though well provided with the essentials for efficient illumination. In neither case does the vicinity of a properly appointed light-house appear to have induced the local authorities to improve their own works. Nor has it incited the keepers to see how their business could be better carried out, although at Peterhead the keeper was anxious to do his duty, and asked the chairman of your Commission to give him a lesson in cleaning reflectors!

At Boddam Harbor, in Aberdeenshire, on the contrary, there are lights of small pretensions, merely extra-sized street lamps, glazed red, with reflectors behind the gas flames, but they are very efficient, because under the charge of an intelligent man, who is an "occasional keeper" at the adjoining Buchan Ness light-house, under the Commissioner of Northern Lights.

Numerous buoys marked the dangers of the Shannon some few years since; they have gradually been washed away, and never replaced. The local government now responsible for properly marking the dangers are, the Harbor Commissioners at Limerick, to whom this charge was transferred from a previous board. It was in the time of the previous board that the buoys were washed away. The revenues are considerable, about £7,000 a year, but are entirely mortgaged to the Board of Works at Dublin, as interest on a debt of over £200,000, a large portion of which, £80,000, as was stated, was expended in building a bridge across the river at Limerick, and an almost useless lock; which former conferred not the slightest benefit on the shipping, whose owners are charged with defraying the interest of the money expended on it. Sums are doled out to the Harbor Commissioners by the Board of Works for any repairs that are absolutely necessary; but these only go to increase the debt, of which about £25,000 consists of accumulated unpaid interest. There appears, therefore, to be but little prospect of the urgent necessities of the shipping that frequent the port being properly supplied, unless the whole question is made the subject of a special inquiry.

At Sligo, the wreck of a yacht, the "Fancy," belonging to the Marquis of Drogheda, may serve as an instance of great neglect on the part of a local authority, either to replace and maintain in its position a buoy that had been washed away, and yet appeared on the charts, or give such information of their intention not to replace it as might ve as a sufficient warning to mariners that the buoy was out of posi- n. The buoy in question had been washed away for more than a r, and had not been replaced, but it still appeared on the latest Ad- ralty charts; and we were unable to find any trace of any communi- ion having been made by the Harbor Commissioners at Sligo to any hority accustomed to disseminate information on such subjects. nce the yacht was lost, and the owner is unable to obtain any re- ss.

Largest local authority--Liverpool.

iverpool is the largest of the local authorities, and has seven light- ses, three floating lights in position, sixty-five buoys in position, and beacons. The numerous and critical channels leading to the Mer- , are marked by these light-vessels, and are admirably buoyed, the oys being generally of a superior description, and effectively main- ned. The same, however, can scarcely be said of the lights on shore. From Aberdeen and many other ports it was impossible to obtain urns, though repeated application was made; but such as have been nished show that almost every authority has some peculiarity in its nstitution or management, and that the management of local lights as various as the constitution of the authorities.

What has been said of the superior authorities is generally applica- e to local authorities also. Those who manage lights are not ap- inted to their offices because they have had any previous knowledge the subject, and those whom they employ may or may not have the quired knowledge. The keeper's salary varies from £200 per annum, ith house accommodation, to 7*s.* 6*d.* per week. without a house, or wer when their whole time is not required. The lights are almost niversally in worse condition and worse kept than those under the rger authorities, and they are inferior to French lights of the same ass, which are under the same management as the great sea lights, nd which are fully equal to them in proportion to their requirements.

Want of uniformity.

As every local authority is independent of all the others, each acts on s own plan, and the result is great inequality and confusion. There no uniformity in tide lights. A red light means danger at one place, nd safety at another; the same number of flags or balls may mean wo different things at neighboring ports. The system of buoyage aries everywhere. Red is left on the one hand in sailing into Hull, n the other in sailing into Liverpool, and the mariner who is familiar ith the Liverpool system meets one which is exactly the reverse in entering the port of Dublin. The Admiralty have adopted at Berehaven a system depending on the points of the compass; at Plymouth, one founded on the knowledge a man has of the distinction between his right and left hand in entering the port. In short, there is no uniformity in the system adopted for local lights, buoys, or beacons, and they are, generally speaking, inferior in quality.

Present power of supervision and control.

Under section 394 of the merchant shipping act, the general lighthouse authorities, with sanction of the Board of Trade, may compel ocal authorities within their several jurisdictions to lay down new uoys, remove or discontinue light-houses or beacons, and vary the haracter of the light-houses or the mode of exhibiting lights. And hey may prevent the construction or alteration of lights by these uthorities.

Under 395, they may apply to the Queen in Council for the transference of the powers of a defaulting local authority.

Under Section 413, a local authority may surrender or sell any light-house, buoy, or beacon to the general authority in the same country, to whom the dues become in future payable.

From the evidence of the general light-house authorities, it appears that these powers have been very sparingly employed; nor do they appear to consider that they have any jurisdiction in regard to the internal arrangements of local lights, or to the maintenance of local buoys and beacons. It should be observed, also, that the act makes no provision for the alteration of the position, color, or character of buoys; hence, there is no power to enforce a uniform system, however desirable such a system might be considered.

Uniform system of tide-lights and signals recommended.

Your Commissioners think it very desirable that a uniform system of tide-lights and signals should be established, instances having been reported to us in which valuable ships have been lost from a mistake in their meaning, or the want of them.

Change in lights, &c., to be more fully notified.

Your Commissioners wish to lay some stress upon the necessity that exists for a more extensive and careful distribution of notices respecting changes in lights, &c., whether belonging to local or general authorities. We would recommend that, in addition to the present issue, as stated in the Admiralty letter of 1st February, 1861, notices should be sent periodically to your Majesty's consuls at the principal ports abroad, and that the several changes of the current year, and the contemplated changes in the ensuing year, should be published quarterly in a cheap pamphlet, purchasable at the shipping offices at home, and at the consulates abroad; and that, in order to insure the masters of ships being provided with these notices, they should form part of the clearing papers of at least those vessels that are bound on oversea voyages.

Further supervision and control of local authorities recommended.

Although aware of the great advantages of local self-government, your Majesty's Commissioners feel that such a state of things as exists in most of the harbors of this kingdom demands the serious consideration of the legislature, and that means should be adopted for permitting the exercise of a more effective control over such local authorities as may persist in mismanaging the interests entrusted to their charge. This control ought to extend at least to the maintenance, character, and color of buoys, to the use of efficient means of illumination, and to the expenditure or improper application of dues. But no such control could be exercised without a knowledge on the part of the controlling board of the actual state of the local lights, buoys, and beacons, and this could be gained only by inspection. Power is given to the Trinity House to enter any light-house within the jurisdiction of the Northern Commissioners or Ballast Board, to view the condition thereof, (section 396), and as the lights of local authorities are said to be "within the jurisdiction" of the general authorities, they may be supposed to be included; but here the permission to inspect ceases, no power being given to the Trinity House to inspect English local lights, or to the Scotch or Irish Boards to inspect the local lights in places under their jurisdiction, nor are either of the three empowered to examine local buoys or beacons anywhere. Nor is it to be expected that were such power simply given to the general authorities it would be exercised by them ıless in special cases. What is wanted, is such a systematic inspecon of all light-houses, floating lights, buoys, and beacons, by some ›mpetent authority, as shall serve the purpose of making known to ıe public, and to the inhabitants of the ports themselves, the merits r deficiencies of the works in question. To gain this object, the in›ector's annual report should be presented to Parliament and pubshed; and further, to facilitate the general distribution of that portion hich relates to the locality, the report might be printed in separate ctions; and the Trinity Commissioners should have further powers reserve, to be called into play in cases of extreme neglect.*

COLONIES.

System of construction, maintenance, and control.

There appear to be at present various systems in force for the *construc›n, maintenance*, and *control* of certain light-houses in the Colonies under e superintendence of your Majesty's Government.

There is a system provided in the merchant shipping act amendment t, 1855, (see clause I to VIII,) which contemplates the erection of ;ht-houses at or near your Majesty's Colonies, with money to be raised the Board of Trade under security of the dues to be levied in respect ereof, (see clause VIII,) and also for placing the light-houses previousexisting, or that may hereafter be erected, under the act which prodes for the levying of light dues in the United Kingdom and Colonies vessels that have passed or are about to pass such lights; providing, ›wever, that no such light dues shall be levied in any Colony without e sanction of the local legislature having been first obtained. The ly light-house erected under these clauses is that on Cape Race, in ewfoundland. It appears that several applications have been made ıder this act, some of which have been declined, and some are still ıder consideration.

The merchant shipping act amendment act appears to have arisen ıt of a correspondence between the departments of the Board of Trade, e Admiralty, the Treasury, the Colonies, and Mr. Gordon, C. E., in hich Mr. Gordon and the Admiralty press upon the attention of the ›ard of Trade the great importance of availing themselves of their ›sition as defined in the merchant shipping act, and urge them to pro›ed to aid in the erection and supervision of light-houses in or near the ›lonies.

There are numerous light-houses in the Colonies to which our inquiry ıder the commission does not extend, as they are not under the supertendence of your Majesty's Government. The Board of Admirality, in ıeir letter of the 6th December, 1854, evidently contemplated a much ore extensive interference by the Home Government with the Colonial ;hts, owing to the unguarded state of the seas bordering upon your ajesty's possessions abroad, and to the bad condition or management some of the existing lights; but the merchant shipping act amendэnt act gives only very restricted permissive power to the Home vernment, and leaves the faulty lights as they were.

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Since the above was written, it has come to our knowledge that the Commissionof Northern Lights recommended a similar system of control to be introduced he first merchant shipping act.

The Board of Trade evidently consider that it is still within their power, and that power will probably be exercised, to maintain certain Colonial light-houses (although erected since the amendment act of the merchant shipping act was passed) entirely from the consolidated fund.

Control over the expenses of constructing certain light-houses in the Colonies is exercised by the home legislature, to whom are submitted all recommendations of expenditure on a Colonial light-house. A certain undefined amount of control over the maintenance and management of some of the Colonial light-houses is recognized as consequent upon, and resulting from, aid more or less partial, having been given from imperial funds or from passing tolls levied in consequence of an act of Parliament to that effect. In practically enforcing this control we suppose the stringency would vary with the amount of the aid given, as compared with the total sum expended.

In respect to scientific points or matters of detail in the management of these lights, we find that the practice of the Board of Trade has been to consult the Trinity House, or its officers, or to follow their procedure.

Insufficiency of present system.

The machinery at the disposal of the Board of Trade for the construction, maintenance, and control of certain light-houses in your Majesty's Colonial Possessions, under the superintendence of your Majesty's Government, appears in certain cases to have been insufficient. This insufficiency is especially apparent in the total failure to erect a light-house at the Great Basses, Ceylon, where, at the end of five years, and after the expenditure of £42,000, a light imperatively called for is not yet commenced, and a most dangerous locality thus remains unguarded until the Board of Trade have received the report of the government of Ceylon on the expense of constructing and maintaining, as substitutes for the proposed light-house, two light-vessels, which have been recommended by the Admiralty surveying officers, specially employed for this purpose. The steps now adopted are those which should have been taken in the first instance, and which we recommend should be adopted for the future. We are therefore of opinion that the systems now in force for the *construction, maintenance*, and *control* of certain light-houses in your Majesty's possessions, under the superintendence of your Majesty's Government, are not well adapted for ensuring the most efficient control of that service with a due regard to economy, and we beg to submit to your Majesty that the following change is required:

CHANGE OF SYSTEM.

Change of system recommended.

Your Commissioners would recommend that the powers of the Board of Trade, with regard to Colonial light-houses, be transferred to the new central authority about to be proposed, and that steps be taken by its members to acquire a complete knowledge of the requirements and legitimate wants of the trade passing near the British Colonial Possessions, so that applications from any particular trade or colony shall not be either too easily granted, or too hastily refused.

To ensure this, we would suggest that the officers of your Majesty's navy, either afloat or on shore, and especially surveying officers, and, in their absence, artillery and engineer officers, be made available for periodical inspection of existing light-houses in the Colonies, and for reorting on petition for new lights, or for transfer of old lights, under he merchant shipping act amendment act, and, also, generally on the vant, if want there be, of light-houses for the safety of the passing rade.

If this practice is adopted systematically, and the naval commander-in-chief be supplied with printed forms, to be returned periodically, the light-house board in England charged with the superintendence of certain Colonial lights will always have in its possession such an amount of evidence collected on the spot by trustworthy and experienced persons as will enable it to come to a sounder decision than can at-present be possible in the absence of any such system.

CHANGE OF SYSTEM OF GOVERNMENT.

Change of system of management and control.

From an early period of our inquiry it has been evident to your Majesty's Commissioners that changes might be advantageously made in the system of management and control under which the light-houses, floating lights, buoys, and beacons on the coasts of the United Kinglom, and certain light-houses in the Colonies, are constructed and naintained. The evils of a double, triple, or quadruple government, he anomalies arising from such a multiplicity of systems, and the want f certain necessary elements in all the managing boards, became more nd more apparent as our inquiry advanced. Yet so complicated was ie question, and so great are the interests involved, that it has deanded long and careful consideration on the part of your Commisoners before deciding on the nature of the change they would recomend. By a sort of exhaustive process, a scheme of government has een arrived at, the reasons for which are more particularly set forth the chairman's letter attached to this report, and whose words in escribing the proposed change we have thought proper generally to lopt.

It was beyond the province of this Commission to recommend any iange in the fund for maintaining lights, buoys, and beacons, but earing in mind the possibility or probability of a change, they have so ranged the proposed scheme of government that it is equally well lapted—first, to the present system of levying tolls on the passing ade; secondly, to a system which has occasionally been suggested, viz., tonnage rate, which promises some advantages, and, in addition to iat of simplicity, a great economy, both of labor and expense, in colection; and, thirdly, to that system which has been recommended to the gislature by the four special committees that have been authorized to reat directly this important portion of the subject, viz: *That the expense f erecting and maintaining our light-houses should be defrayed out of the pubc revenue.*

Had the question submitted for the consideration of your Majesty's ommissioners been how to form the most perfect system of light-house ianagement for the first time, we should probably have suggested a impler and more responsible form of government; but, regarding the ubject in all its bearings, as we were bound to do—considering the existng almost national institutions, the extent of practical knowledge ossessed by them, as well as the large machinery employed—we have eemed it expedient to build on existing foundations rather than to re-construct out of entirely new materials; and we, therefore, recommend that the government and management of lights, buoys, and beacons of the United Kingdom, and of certain light-houses in the Colonies, be vested in a new central authority, to be denominated the Trinity Commissioners for Lights, and that the expenditure of such Commissioners be brought directly under the control of the House of Commons by an annual submission of their estimates, through the Board of Trade or the Board of Admiralty, as may be deemed best, and that when once the estimates have been approved of by Parliament the expenditure of the funds voted be entrusted to the sole discretion of the Trinity Commissioners, under the recognized system of imprest and audit.

Central Authority recommended.

To constitute this *central authority*, to be denominated the "Trinity Commissioners for Lights," it is proposed that four members be elected by the Elder Bretheren, in such a manner as will ensure the retirement and election, after the four first years, of one member annually, and that to these four be added one member for Scotland, to reside in Edinburgh, and another for Ireland, to reside in Dublin, elected every four years, the whole to be eligible for re-election; and, in addition to the above six members, who should be engaged in no other business, that one other member be selected by the Government with special reference to his scientific acquirements in those branches of knowledge which relate to coast illumination, as enumerated by us in Circulars IX and X, the whole subject to the approval of Government, and to have salaries commensurate with the importance of the duties and with the necessary engagement of their time. To these it is proposed to add the Astronomer Royal, the Hydrographer of the Admiralty, the Comptroller General of the Coast Guard, and one of the professional members of the Board of Trade, which last four persons would be ex-officio "Trinity Commissioners for Lights," and should be liberally paid for their attendance at the weekly boards, or oftener if summoned.

The appointment of a governing body such as is sketched out above implies the transference to it of the light-house duties of the Board of Trade, Trinity House, Commissioners of Northern Light-houses, and Ballast Board; and we recommend that the election of the Scotch and Irish resident members should rest with the public bodies whose members have so long and so zealously, and without gratuity, performed the light-house duties in the two countries; and, for the purpose of selection from time to time, it would be highly desirable that the Commissioners of Northern Light-houses should continue to exist as a body, constituted as at present.

The members who would thus be resident in Scotland and Ireland, and whose duties in those countries would be generally executive, should receive the same salary as the four executive members of the Central Board selected from the Elder Brethren; and as the subject of new works and changes would probably only be discussed at collective meetings in London, and at a time when the estimates were being prepared for Parliament, it would be proper that they should attend in London at that period, and on other occasions when summoned by the Central Board.

In addition to the increased responsibilities to be vested in the new governing authority, we recommend that the whole of the local lights and buoyage in this kingdom be subjected to an annual inspection under the direction of the Trinity Commissioners for Lights, and an annual report of the same be presented to Parliament with the light-house estimates; that the powers already vested in the general light-house authority with regard to local lights, &c., by various acts of Parliament, be put into more active operation; and that further powers be given, as already stated; and in the event of the expenses for lights, &c., being defrayed out of the public revenue, that the Admiralty lights, beacons, and buoys, exclusive of mooring and warping buoys, be given over to the same body.

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VISITATION OF THE ROYAL SOCIETY.

Royal Society to visit.

In order to satisfy the public that our light-houses, and the whole system of light-house illumination, are in all respects what the highest state of science can produce, and the interests of this great maritime country require, your Commissioners would recommend that your Majesty should he advised to issue your warrant appointing the President and Council with other Fellows of the Royal Society annually to visit the central establishment of the Trinity Commissioners, as is now the case with the Royal Observatory; and that the Trinity Commissioners for Lights should on that occasion submit a report of their proceedings in all matters relating to the development of and improvement in light-house illumination to the Visiting Board of the Royal Society; such report to be presented to Parliament with the annual estimates.

* * * * * * *

In the various statutes establishing the authorities and duties of the Trinity House, the office of the Lord High Admiral or that of the Commissioners for executing that office is frequently referred to; and it is impossible to read the evidence taken by the committees successively appointed by Parliament, in 1822, 1834, and 1845, to inquire into light-house management, or the correspondence in the last twenty years between the Admiralty, the Board of Trade, and the Colonial Office, respecting colonial lights, without it being apparent that not only the Board of Trade, but the Trinity House also, have more or less leaned upon the Admiralty in fulfilling their duties, and that there must lways be an official and essential relation betwixt the light-house serice and the Admiralty; but although the dependence of the one upon he other of these departments has in no degree diminished, but rather he contrary, yet in the merchant shipping act, 1854, this connection is nored, and the Admiralty nowhere appears in our light-house polity, set forth in the act.

Nevertheless, the Admiralty is that departmment of the Government hich more than any other possesses the means for effectually assisting carrying on the light-house service. These means consist of its able drograpic staff, both at home and abroad, and the necessary affinity isting between that staff and the light-house service, as shown in the dmiralty letter of 1st February, 1861, its present complete chain-work coast-guard stations and flotilla, under intelligent naval officers, at ery point of the coast, and its employment of the ablest engineers of is country, whose estimate for a work, when once admitted, would arcely admit of the prejudicial disputes which now retard the prosetion of important works.

On the other hand, we have the Board of Trade, a department having the general superintendence of matters relating to merchant ships and seamen, and which, since the passing of the merchant shipping act, 1854, has had control over the three general light-house authorities, and in its six years' exercise of that control much valuable experience must have been gained by it. It is also the department at present representing the light-house authorities in Parliament. It has, so far as the limited machinery at its disposal admits, devoted great attention to light-house business, and has most scrupulously kept in check all light-house expenditures; whilst, under the system as now proposed, the Board of Trade would have one of its professional members an ex-officio member of the new central body.

Presentation of estimates.

Leaving, it then, an open question, to be decided by the Government, whether the Board of Trade or the Admiralty is for the future to represent our light-house government in Parliament, and reverting to the unanimous opinion of the several Parliamentary committees, embodied as those opinions are in the recommendation of the committee of 1845, viz: *That all expenses for the erection and maintenance of light-houses, floating lights, buoys, and beacons, on the coast of the United Kingdom be thenceforth defrayed out of the public revenue,*" the representative duties would be confined to the presentation of estimates of a simple nature prepared by the Trinity House Commissioners in a comprehensive form, and the acquiring of information necessary for the full explanation of these estimates to the House of Commons; neither of which would involve an amount of trouble deserving of any consideration in weighing the relative advantages possessed by the two departments, or in deciding which is most likely to afford the largest amout of material support to the Commissioners appointed to carry out the light-house service of the country.

CONCLUSION.

* * * * * * *

We have already spoken of what is owing to the Astronomer Royal, and to those scientific men who have generously, and at the cost of valuable time, furnished such replies to our questions as cannot fail to be of use in the furtherance of an important science; and in the proposals sent to us by manufacturers and others for improvements in tide-lights, in the build of light-ships, in lamps, &c., there is ample evidence of the skill and ingenuity available in this country for further facilitating the navigation of these shores.

In conclusion, your Commissioners would humbly express their hope, that the attention which they have given to the subject of the inquiry which they were commanded to undertake, may not be entirely fruitless; and that the remarks and observations contained in the report now humbly submitted to your Majesty, may result in an improvement in light-house illumination, in a more complete system of lighting and marking the shores of your Majesty's dominions, and in the furtherance of the interests of commerce and of humanity—interests which your Commissioners are fully sensible must ever hold a high place in your Majesty's regard.

All which we humbly submit to your Majesty.

Witness our hands and seals this 5th day of March, 1861.

W. A. B. HAMILTON. [L. S.]
ALFRED P. RYDER. [L. S.]
J. H. GLADSTONE. [L. S.]
DUNCAN DUNBAR. [L. S.]
S. R. GRAVES. [L. S.]

J. F. CAMPBELL, *Secretary.*

LETTER

OF THE

CHAIRMAN OF THE ROYAL COMMISSION

ON

LIGHTS, BEACONS, AND BUOYS.

After our many discussions on light-house government, I think I have gathered what would most probably be the views of my colleagues on that subject; I propose, therefore, to put in writing what I believe those views generally to be; and if I succeed in my interpretation of them, the following paper may aid in the completion of that part of our report which relates to management and control.

W. A. B. HAMILTON.

JANUARY 10, 1861.

Range of inquiry of the Commission.

1. It has been necessary, during our inquiry, to bear in mind that it is not with the whole of the duties of the Corporation of Trinity House that this Commission has had to do, but with those only which relate to lights, buoys, and beacons.

2. The same consideration was necessary in investigating the Irish light-house system. It was not with the Ballast Board of Dublin, as a corporation, that we were dealing, but only so far as respects its management of lights, buoys, and beacons.

3. It is different, however, when we come to Scotland. There we have a board, the only light-house board (in the ordinary meaning of the term) in the kingdom, and this board is denominated the Commissioners of Northern Light-houses.

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Members of Corporation of Trinity House, whence selected.

5. The members of the Corporation of Trinity House are self elected; and although the acting members appear to be selected from amongst the most respectable of the commanders of our mercantile navy sailing out of the port of London, they are not chosen for any special qualification they may possess for the scientific duties connected with light-house service.

Ballast Board, when established, and for what purpose.

6. In Ireland, the members of the Ballast Board, a corporation instituted by act of Parliament in 1763, for preserving and improving the port of Dublin, are not even nautical men, with the exception of one retired naval officer; nor does it contain amongst its members any, with the above exception, that have been selected with reference to light-house requirements.

Scotch Board, when established, and for what purpose.

7. With respect to Scotland, a board, consisting of two law-officers of the Crown, the sheriffs of certain maritime counties, the provosts of certain royal burghs, and the provost of Greenock, was especially established in 1780, by act of Parliament, for the management exclusively of lights, &c., in that country. As is the case in the Irish Board, provi-

sion does not seem to have been made in that act for the members of the Scotch Board being persons conversant with light-house science or management; but in the exercise of these duties, special care has been taken by the Commissioners of Northern Light-houses to secure the services of persons who were possessed of the necessary qualifications.

Light-house authorities.

8. We have thus, properly speaking, to deal with two corporations, the Trinity House in England, and the Ballast Board in Ireland, (but only as regards that portion of their duties which relates to lights, &c.,) whilst in Scotland our business is simply with a light-house board.

Executive light-house business at the Trinity House conducted by two committees.

9. To illustrate the above, we have only to turn to question V, Circular No. 1, "Constitution of General Authorities, England," where we shall find, that of seven committees into which the twenty acting Elder Brethren of the Trinity House are divided, for the general business of that corporation, one only, "The Committee of Light-houses," consisting of four or five members and the chairman, is required exclusively for the executive business of lights, buoys, and beacons; and that they meet but once a week as a committee for that business; at the same time, it forms part of the duties of another committee, viz., "The Examining Committee," annually to inspect the sands between Yarmouth and the South Foreland, and other localities where changes are likely to have taken place; and it is under the supervision of this last committee that all notices to mariners are framed and issued; but the duties of both committees are purely administrative, jurisdiction resting with the enire board, whose sanction has to be obtained before any recommendation of a committee can be carried into effect.

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Executive business of Irish lighthouses, conducted by two committees of the Ballast Board.

10. Again, with respect to Ireland: The answer to question 2, Circular No. 1, shows that out of nine committees into which the Corporation of the Ballast Board, consisting of twenty-three members, are divided for conducting its business, two only are specially appropriated to the executive business of the Irish lights. These two committees are entitled the light-ship, and the inspecting committees. The former consists of five, and the latter of six members, all unpaid. Important questions relative to light-houses receive the consideration of the whole of the Ballast Board.

Nature of business, and number of members composing Scotch Board.

11. The Scotch Board, as before stated, has none other than lighthouse business to attend to; and is composed of twenty-eight unpaid commissioners, though, under an act subsequent to that of 1786, provision is made, under certain circumstances, for an addition to those members.

PROPOSED CENTRAL BOARD.

Views of Parmentary Committees as to the expediency of one central lighthouse board.

12. This Commission can hardly have arrived at the present state of its inquiry without having come to the conclusion, that the several Parliamentary committees that have been appointed from time to time, since 1822, to inquire into the management of light-houses in this country, were justified in the view they took (without exception) of the expediency of those light-houses being under the management of one board, resident in London.

Question as to composition of a central board.

13. The question now arises, admitting the necessity of such a board, whether there exists materials or a groundwork on which an efficient central board could be constituted? and this is a point upon which,

after our long and careful investigations, we are in a position to form some conclusion.

Trinity House Committee for light-houses the groundwork for a central board.

14. I have said above, that the members of the Corporation of Trinity House are not selected for their special qualification for light-house business; but this Commission has been brought in contact with most of the gentleman of that corporation who compose its present committee for light-houses, &c., and I am sure that my colleagues must be satisfied as to the general ability, the intelligence, and the anxious desire of those gentlemen to fulfil the duties devolving upon them. The system of their election from among the Elder Brethren of the corporation is stated; and, adopting such a committee as a nucleus or basis upon which to frame a central board, let us consider the sort of infusion necessary to complete it.

Necessity for introducing new elements.

15. It is manifest from our inquiries, that the elements essentially wanting are the *scientific* and the *hydrographic;* and these considerations have to do with the composition of the new central board as well as its staff.

16. The numbers as well as the qualifications of the members necessary for composing a central board will now have to be considered.

Numbers and composition of the new central board.

17. Of the five Elder Brethren who now constitute the present committee for light-houses, we find that not more than four are in regular attendance; and that number might be adopted as constituting the Trinity House proportion of a central board, to be denominated the "Trinity Commissioners for Lights," such four members to be elected by the Elder Brethren, subject to the approval of the Government, and to have such addition to their present salaries as might be considered commensurate with the increased importance of their duties, and with the necessary engagement of the whole of their time, and to these four should be added one member for Scotland, to reside in Edinburgh, and another for Ireland, to reside in Dublin; and in addition to the above six members, one other member should be selected by the Government, with special reference to his scientific acquirements in those branches of knowledge which relate to coast illumination, as enumerated by us in Circulars 9 and 10, with a suitable salary. To these should be added the Astronomer Royal, the Hydrographer of the Admiralty, the Comptroller General of Coast Guard, and one of the professional members of the Board of Trade, which last four persons would be ex-officio "Trinity Commissioners for Lights," and should be liberally paid for their attendance at the weekly boards, or oftener if summoned. It would be competent, of course, to the Government to increase the number of the central board.

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Royal Society annually to visit central establishment.

19. And in order to satisfy the public that our light-houses, and the whole system of light-house illumination, are in all respects what the highest state of science can produce, and the interests of this great maritime country require, the Queen might be advised to issue her warrant appointing the President and Council with other Fellows of the Royal Society annually to visit the central establishment at the Trinity House, as is now the case with the Royal Observatory; and that the Trinity Commissioners for Lights should on that occasion submit a report of their proceedings in all matters relating to the development of and improvement in light-house illumination to the visiting board of the Royal Society; such report to be presented to Parliament with the annual estimates.

STAFF OF CENTRAL BOARD.

Numbers and composition of the scientific portion of the central staff.

20. The next point for consideration is, the staff for the proposed central board. All our observations—all our experiments, go to show that qualifications of a special order, such as are only to be found in a person trained to the business of what the Astronomer Royal, in his letter of the 10th November last, aptly terms an "Optical Engineer," are absolutely necessary. The qualifications that such a person must bring with him are clearly set forth in that valuable paper; and it might be necessary, for purposes hereafter to be mentioned, that such officer should have the assistance of three Assistant Optical Engineers, (who will also be "Inspectors of Lights,") one for England, one for Scotland, and one for Ireland. * * * *

Better application of Professor Faraday's services.

21. It is true that at first sight the Trinity House would seem to be supplied with all that could be required of an Optical Engineer and Inspector of Lights; for the Elder Bretheren have had at their command, and have, to a certain extent, availed themselves of the talents and genius of a Faraday, and to say that science were wanting where Professor Faraday is the scientific adviser, would seem to be a contradiction in terms; but it was necessary, as this Commission have seen, to turn those talents and that genius in the required direction to secure to the science of light-house illumination that perfection which it has been the aim of this Commission to prepare the way to; and it was in consequence of the researches and experiments of this Commission that the great talents of Professor Faraday were directed to those points which we now find essential for the best production of light, its perfect adaptation to costly illuminating apparatus, and the most correct adjustment of that apparatus for light-house purposes.

Prof. Faraday should be properly remunerated for these services, when more properly applied.

22. All these are subjects that a Faraday's powers have promptly mastered since attention has been called to them by this Commission; but precisely in proportion to the great scope of his talents is the difficulty of their being absolutely and at all times at the command of the Trinity Commissioners for Lights; for, assuming for the moment that Professor Faraday were the Optical Engineer to the new board, that appointment must carry with it the employment of his whole time. The scientific world, however, could not afford that a Faraday's talents should be *entirely* devoted to light-house duties, but whatever portion of his valuable time and peculiar talents he can afford to the Central Board, for that time and for the use of those talents he should be amply remunerated.

Transference of the duties of the Scotch and Irish Boards.

23. The appointment of a central governing board, as above sketche out, implies the transference to it of the light-house duties of the Scot and Irish Boards; but the absolute necessity for thus simplifying th present combersome scheme of government has been apparent to u from the first, and does not necessarily imply the slightest reflection o the management of those boards, which will for the future be represented by the two commissioners to be elected by those boards.

Merits of Scotch and Irish Boards.

24. I do not now enter at large upon the respective claims of eac but while the Scotch and Irish Boards are not without their meri and may fairly be described as light-house establishments, worki under difficulties, the Scotch Board deserves to be especially prais for the admirable management of its lights, though the costliness o

some of its works, (a costliness probably of easy explanation,) in some measure accounts for what would otherwise seem to be an over jealous exercise of control on the part of the Board of Trade.

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Precedents for erecting and maintaining light houses from imperial funds.

30. The principle that the cost of *erecting* and *maintaining* light-houses may be defrayed out of the public revenue appears to have been already sanctioned by Parliament; for, looking to the merchant shipping act amendment act, 1855, and to the Board of Trade's letter to this Commission, dated 25th January, 1860, it seems that some of our Colonial light-houses have been *erected* and are to be *maintained* by imperial funds until such time as the colony is in a position to maintain them itself; and that others, such as the light-house at Cerigo, have been *erected* with imperial funds, and are *maintained* jointly by Her Majesty's Government and the Ionian Government; that the cost of *erection* of the Roman Rocks light-house, at the Cape of Good Hope, is to be borne by imperial funds; and that sums from time to time voted by Parliament for the *erection* of light-houses at the Great Basses, at Vancouver's Island, and at Cape Point light-house, Cape of Good Hope, and that Parliament will be asked for additional sums for the same purposes. This practice, sanctioned by the legislature in so many instances, is, in a certain sense and to a certain extent, giving effect to the recommendation of the various Parliamentary Committees that have been appointed since 1834, (including the committee on merchant shipping appointed in this year,) viz: *that the expense of maintianing our light-houses, &c., should be defrayed out of the public revenue.* In speaking, therefore, of a change in the system of light-house government, although it may be beyond the province of this Commission to pass an opinion as to the mode of raising the fund for maintaining the lights, &c., or to say out of what funds provision for the expenses of lights, buoys, and beacons should be made, yet this is a question impossible to be lost sight of in considering the form of government best adapted for our light-house system.

31. And herein lies our difficulty, that we are directed "*to inquire whether the present system of management and control under which the light-houses, floating-lights, buoys, and beacons on the coasts of the United Kingdom are constructed and maintained according to the provisions of the 'merchant shipping act,* 1854,' *is well adapted for securing the most efficient lighting and buoying of the coasts of the United Kingdom, with a due regard to economy; or whether any, and if any, what change might be advantageously made in that system;*" and whilst (as is the case) our inquiry has led to the conclusion that some change is required, in order to "*secure the most efficient lighting and buoying of our coasts,*" and we are prepared to recommend a change, we are met at the outset by that clause in our instructions which would seem to point to the existing provisions of the "merchant shipping act"—an act which, by transferring the light dues to the mercantile marine fund, does at the same time give to the Board of Trade the entire control over those authorities who are really chargeable with "*the lighting and buoying of our coasts.*"

Proposed change adapted to present system of levying tolls, or to other modes of providing funds.

32. If, therefore, the proposed change should at all appear to be a step beyond the bounds imposed upon us, yet it may be allowed to possess this advantage, that if not strictly adapted to the present "*provisions of the merchant shipping act,*" it is at least adapted, first, to

the present system of levying tolls on the passing trade; secondly, t system which has occasionly been suggested, viz., a tonnage rate, wh promises some advantages, and, in addition to that of simplicit great economy both of labor and expense in collection; and, thir to that system which has been submitted to the legislature by the f special committees that have been authorized to treat directly t important portion of the subject, viz., *that the expenses of erecting maintaining our light-houses should be defrayed out of the public revenue.**

Necessity for Parliamentary representation.

33. Whether the funds to be provided for the light-house ser continue to be raised by dues, or by the simpler and more econom mode of a tonnage rate, or ultimately from imperial funds, the mates regulating the amount of these funds will have to be submi to Parliament; and as the proposed central board would not be re sented in and would not be directly responsible to Parliament, s department of government will have to present the estimates to House of Commons, and whatever that department might be, it w necessarily in some sense be responsible for those estimates; but responsibility should extend no further than to the being able full explain the several items of those estimates to the House.

Present complicated system of government.

34. The 422d section of the merchant shipping act, 1854, prov that "each of the general light-house authorities shall from time to submit to the Board of Trade estimates of all expenses to be incu by them." Doubts are entertained by the above authorities as to strict legality of the Board of Trade's interpretation of that sectio exhibited in their minute interference with the mode in which t authorities carry out their works after the estimates for them been finally approved by the Board of Trade; but, setting aside t doubts for the moment, and without dwelling at any length on the considerable increase of correspondence arising out of that act, without referring to the prejudicial delays that may be attribut the present working of that particular section of it, it is diffic discover the necessity for that cumbersome system which now e under the two acts—the merchant shipping act amendment act, and merchant shipping act, 1854, viz: *A single government* (the Boa Trade) for light-houses in the British possessions abroad; *a doubl ernment* for the light-houses under the Trinity House; *a triangular g ment* for the Scotch light-houses and for local lights in England; *quadrilateral government* for the Irish light-houses and for local l in Scotland and Ireland—a system which can scarcely be expect find favor in the present day.

Insufficiency of machinery at the command of Board of Trade.

35. The machinery at the disposal of the Board of Trade, in that relates to "*the construction, maintenance, and control of certain houses in our Colonial Possessions,*" would appear, from certain paper from parts of the evidence that have come before us, to be in some insufficient. It cannot be denied that this insufficiency is in a degree made up for by the talent and assiduous devotion to their d

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* The saving of a considerable sum incidental to the collection of light due be borne in mind as connected with the question of their abolition. At the Liverpool five clerks, with an aggregate salary of £1,098 10s., are required calculations and collection of light dues; and at the port of London the sala the clerks fulfilling those duties, including the collection of the Trinity Hous dues, amount to £800 a year. The salaries of clerks employed at the Trinity for examination, &c., of accounts for collection amount to about £700 a year.

of those officers of the Board of Trade on whom the light-house business devolves.

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BOARD OF TRADE OR ADMIRALTY TO REPRESENT LIGHT-HOUSE BOARD IN PARLIAMENT.

36. The question now arises, what public department of the Government could most advantageously be connected with the new Light-house Board, and be charged with representing that board in Parliament.

37. In the various statutes establishing the authority and duties of the Trinity House, the office of the Lord High Admiral or that of the Commissioners for executing that office is frequently referred to; and it is impossible to read the evidence taken by the committees successively appointed by the Parliament in 1822, 1834, and 1845, to inquire into light-house management, or the correspondence in the last twenty years between the Admiralty, the Board of Trade, and the Colonial Office, respecting Colonial lights, without it being apparent that not only the Board of Trade, but the Trinity House also, have more or less leant upon the Admiralty in fulfilling their duties, and that there must always be an official and essential relation betwixt the Trinity House and the Admiralty; but, although the dependence of the one upon the other of these departments has in no degree diminished, but rather the contrary, yet in the merchant shipping act, 1854, this connection is ignored, and the Admiralty nowhere appears in our light-house polity, as set forth in that act.

Dependence of the Trinity House on the Admiraly.

38. Nevertheless, the Admiralty is that department of the Government which more than any other possesses the means for effectually assisting in carrying on the light-house service.

Admiralty might co-operate in light-house service.

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41. Leaving it, then, an open question, whether the Board of Trade or the Admiralty is for the future to represent our light-house government in Parliament, and, reverting to the unanimous opinions of the several Parliamentary committees, embodied as those opinions are in the recommendation of the committee of 1845, viz: "*That all expenses for the erection and maintenance of light-houses, floating-lights, buoys, and beacons on the coast of the United Kingdom be thenceforth defrayed out of the public revenue,*" and assuming that the time is not far distant when the present ex-officio necessity for the Board of Trade being the representative in Parliament of our light-house government will naturally cease,* it might not be unnatural that the Admiralty, as able materially to co-operate in the light-house service, should be selected to represent that service in Parliament, in which case the duty of such representation would devolve upon a department with which the Trinity House has from the first had real affinity, whilst we should at the same time be assimilating the light-house government of this country to the systems most generally adopted abroad.

Open question whether Board of Trade or the Admiralty should represent in Parliament.

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* Whilst, in this country, where we have 404 light houses and floating-lights (general and local) every foreign vessel has to pay light dues, in America, where there are also upwards of 400 light-houses and floating-lights, no charge whatever is made on British ships. In France it is the same, though it should be stated that in that country the port charges, which are heavier than in ours, are made to contribute to imperial funds, and may fairly be said to include these dues; nor are any charges for lights made on British ships entering any of the ports of Russia, Prussia, Holland, &c.

Light-house system capable of improvement.

44. The state and condition of our light-houses, and the effectivene
of the lights themselves, admit of favorable comparison with the gre
mass of lights and light-houses abroad, with the exception of some
the lights in France; but there is room for improvement, and the exi
ing system is scarcely the most favorable for that improvement. Un
this system the control and management of our lights has passed i
the hands of the Government, but as matters stand there is no depa
ment of the Government which possesses machinery fit for the purpo
The Board of Trade is at present the governing body, and it is in t
actual exercise of functions which, as that department is now consti
ted, it is scarcely equal to, or was probably intended to fulfil. At t
same time, it must be admitted that, even before the application of su
control, the progress of our light-house authorities, at least in Engla
and Ireland, whether in light-house science or management, had scar
ly been in keeping with the state of science in this country; but wit
central board, as now proposed, and in itself responsible, improvem
might be expected, and it ought in its management to keep pace w
the times.

Anomaly in present system of light-house government. Light house science and management would probably advance under proposed scheme of government.

Central board to have control over light-house expenditures.

45. "*The great safeguard of human life on our coasts is the lighting u
our reefs and headlands, and this can be accomplished only by public boa
composed of qualified individuals, and possessing ample resources and exten
jurisdiction.*"* In a central board of eleven members, composed as
been suggested, there can be no doubt that we should have a body
to manage its own affairs, without that description of check and cont
which is now exercised over the three light-house authorities; and
may feel satisfied that in estimates which would be prepared under
superintendence of such central board, the strictest regard would
had to the economical and just application of its funds consistent w
the one paramount object of the proper lighting of our coasts, and
maintaining in the utmost efficiency our national light-house syst
and it may be presumed, that those great interests—the interests of
manity, of navigation, and of commerce—which our light-house gove
ment is intended to serve, would be best promoted by providing t
the light-house estimates should be presented to the House of Comm
as prepared by the Trinity Commissioners for Lights, to be dealt w
by Parliament as is the case with other estimates coming before it.

Course by which alone conclusions have been come to.

46. In conclusion, I need hardly remind my colleagues of our nun
ous and anxious conferences on the subject of light-house managem
and control, and that it has been by a sort of exhaustive process t
the scheme of government above proposed has been arrived at;
need I now allude to our long and careful investigations, the many
periments we have ourselves originated and in great measure c
ducted, nor to that constant and anxious consideration which we h
given to this portion of our inquiry.

SUMMARY OF PROPOSED GOVERNMENT.

Summary.

To sum up the above proposal: The government and managemen
lights, buoys, and beacons in the United Kingdom, and of certain lig
houses in the Colonies, should be vested in a new central board, (c
stituted as already stated,) and to be denominated the Trinity Com

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*British Light-house System, by Sir David Brewster, LL.D., F.R.S., Princ
and Vice-Chancellor of the University of Edinburgh.

sioners for Lights, subject to the annual visitation of the Royal Society; the Board of Trade or the Admiralty to be the department that would present to Parliament the light-house estimates, as prepared by the Trinity Commissioners; whilst, as regards expenditure, after those estimates have passed the House of Commons, the central board should have the entire control.

THIRTY-FIRST MEETING.—APRIL 29, 1859.

Present: Admiral Hamilton, Mr. Graves, Dr. Gladstone, Captain Ryder.

Mr. Allen attended, and stated that the magneto-electric light would not be exhibited after Monday night at the South Foreland.

At 4.30, the Commission decided to visit the South Foreland, and adjourned, in the first place, to Adam street, Adelphi, to inspect a lime light.

Lime light.

The light is on the same principle as Drummond's, but varies in the shape of the prepared lime on which the oxyhydrogen blow-pipe flame plays, and it has also three jets instead of one. The prepared lime is pushed slowly upwards as it is worn away by the heat, and is prevented from falling outward by a series of wires.

The light was brilliant and steady. The French Superintendent of the Light-house Board, Mons. Renaud, was present, and he, as well as many other gentlemen, expressed admiration at the light.

Mr. Graves, Dr. Gladstone, Captain Ryder, and the Secretary started from London Bridge at 8.30 p. m. Dr. Gladstone, on arriving at Dover, proceeded to the South Foreland, while the others embarked for Calais, and observed the electric light from the steamer. (Dr. Gladstone's report follows.)

Electric light.

The light was far brighter than any of the others visible either on the French or the English coast.

It was steady. It seemed to be obscured for a time twice during the passage, but it subsequently appeared, from Dr. Gladstone's report, that the seeming obscuration might (as was suspected) have been caused by the passage of the steamer through the shadow of one of the bars of the lantern. No alteration in the light was observed by Dr. Gladstone, who was at the light-house, but the shadow of the bars were clearly visible in the air close to the light, and must have obscured it at a distance.

Appearance at sea.

From Calais the electric light appeared like a large star on the horizon, with a bluish tinge, while the lower South Foreland light, catoptric, oil lamps, though clearly visible, was less bright, and yellow, or rather orange.

Evidence.

The sailors on board the steamer estimated that they could see the electric light for thirty minutes after losing sight of the lower light, that is, according to the rate of the steamer, at a distance of about seven miles.

They had seen it in thick weather when the other was invisible.

The light at Grisnez, as seen from Dover, was about equal to the lower South Foreland light, as seen from Calais.

The electric light, at a distance of some miles, threw a shadow which could be seen clearly on the palm of the hand, and still more clearly on a white surface.

Colored lights. With respect to colored lights, it was observed that a blue light at Dover was lost when the common town lamps became invisible; that a white light at Calais pier was first seen, next a red light, and lastly, a green.

Color of buildings. With respect to the color of light-houses, it was observed that the light-house against the sky was difficult to make out clearly, when the lower light-house, against a dark background of grass, was easily made out: both are white. That the dark shadow inside the lantern, seen through the glass of the upper light-house was better seen than the white wall against the sky as a background, and that the dark part of the lower light-house at the same time was invisible, while the white wall was clearly seen against the grass.

It appears to follow—

Conclusions. 1st. That the electric light should be fully tried, and that on its success should depend a consideration of its application to certain points of the coast.

2d. That red and green are better colors than blue, but that white is more powerful than any color.

3d. That light-houses and beacons, and buoys, should be colored with reference to the background against which they are seen.

The Commissioners visited the South Foreland light-house after landing at Dover, and were much pleased with its condition, and with the intelligence and readiness of the keepers.

They inspected the electric light, and the apparatus by which it was produced. They conversed with Professor Holmes, who explained the working of his apparatus. And they afterwards returned to London by the 12 train.

Dr. Gladstone reported:

Observations by Dr. Gladstone. The principle of the magneto-electric light is as follows: The power that produces the light is resident in a large number (36) of permanent magnets ranged on the periphery of two large wheels. This

Engine. power is called into action by a steam-engine of two-horse power, which causes a series of soft iron cores surrounded by coils of wire to rotate past the magnets. The small streams of electricity thus generated are collected together into one stream, and by a special arrangement, the alternate positive and negative currents are all brought into one direction. The whole power is then conveyed by a stout wire from the engine-house to the light-house tower, and up into the centre of the illuminating apparatus. There it passes between two charcoal points, producing thus a most brilliant and continuous light. The "lamp" is so contrived, that by means of clock-work and a magnet, around which the wire coils, the charcoal points are kept always at a proper distance apart. The charcoals last three hours, after which the "lamp" has to be changed, but the transition of the current is instantaneously effected, and the light is brought into the focus within [illegible].

Its appearance. The attendant can judge of the position and brightness of the light by watching where one of the luminous beams is thrown on the dark wall of the lantern, and thus he is not required to look at the brilliant point itself. As arranged at the centre of the large dioptric apparatus at the South Foreland, the electric light gives scarcely enough divergence, and dark shadows are cast by the framework of the apparatus and lantern, notwithstanding a special contrivance of reflectors partially to obviate this; but from the luminous point being so small, and no draft of air being required, nor any soot or smoke being produced, it is evident that an arrangement of lenses, prisms, or reflectors, might be made in a very small space, and perhaps the difficulty of the frame-work might be entirely overcome. The working expense of the magneto-electric light consists of the coals consumed, and the charcoal points, with the wear of the machinery, and the wages of an engineer in addition to the ordinary light-house keepers.

Reflectors.

Lenses.

Cost.

At a distance of one or two hundred yards, the magneto-electric light appeared incomparably more brilliant than that exhibited by the lower light-house, which is fitted with fifteen parabolic mirrors kept apparently in the highest state of polish. Dr. Gladstone remarked the great cleanliness and order observed in the lower as well as the upper light-house.

Brilliancy.

Comparison.

The electric light appeared of a blueish white in comparison with all other artificial lights in view, caused a remarkable fluorescence in the glass of the apparatus, and illuminated the atmosphere in such a manner as to produce singular optical effects both near at hand and at a distance.

Electric light.

Observations by the Chairman, Admiral Hamilton.

Admiral Hamilton visited the South Foreland light-house on the night of the 4th of May, arriving at the light at 9 p. m., and quitting at 11.30 p. m. Professor Holmes was on the spot, and explained minutely the principle of the magneto-electric light, and all the details of the apparatus. It appeared that there was the greatest facility in managing the light, and that very common care was required to insure its regular exhibition. During Admiral Hamilton's stay at the light it was visited by a pilot, an intelligent young man, (by name Goldsack,) who had had constant opportunity of observing the light from the Channel since its exhibition, and who bore strong testimony to its great brilliancy and efficiency and greatly regretted its contemplated removal. In this regret Admiral Hamilton cordially joins; for it would seem to be a waste of money, now that the whole machinery is working well, to extinguish the light without a further opportunity being afforded of testing its merits as compared with other lights. Admiral Hamilton cannot but be of opinion that a fuller opportunity and more extensive means, not only of testing the working of the light, but of enabling mariners to judge of its efficiency, and to make their comparisons with respect to other lights, should be afforded. He understands that Professor Faraday has reported on the magneto-electric light to the Elder Brethren of the Trinity House, and he considers it would be right that this Commission should request to be favored as early as possible with a copy of that report, in order that such steps may be taken as the Commissioners may deem fit, with a view to a further trial of the light, it being reported to the Commission that it is intended to remove the whole apparatus immediately. Admiral Hamilton also visited the lower South Foreland light-house, returning to Dover at 12.20, (night.) The light (magneto-electric) was observed from Dover pier at 12.30. Admiral Hamilton returned to town next morning.

Evidence.

Observations.

Conclusions.

He was much struck with the cleanliness and perfect order of the North and South Foreland light-houses, and the manner and intelligence of the light-house keepers.

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REPORT ON THE MAGNETO-ELECTRIC LIGHT ESTABLISHED BY PROFESSOR HOLMES AT THE HIGH LIGHT-HOUSE, SOUTH FORELAND.

ROYAL INSTITUTION, *April* 29, 1859.

Professor Faraday.

The light applied in the South Foreland upper light-house is an electric light; not produced, however, by a voltaic battery, but by magneto-electric induction. In the year 1831,* it was discovered that when a piece of soft iron, surrounded by a metallic wire, was passed by the poles of a magnet, an electric current was produced in the wire, which could be exalted so as to give a spark. The apparatus of Professor Holmes, which is figured and described in the accompanying paper A, consists of an accumulation of powerful magnets and iron cores with surrounding coils, accurately arranged, so that when the associated cores are revolving, they send all their currents into one common channel, from whence they are conveyed to the lantern by conducting wires, and there produce the electric light. There is no consumption of material or energy, other than that of the burning fuel required at the steam-engines to produce motion.

A trial of the light began in the light-house on the 8th of December, 1858; but as the apparatus was imperfect in some points and the results unsatisfactory, the lighting by the apparatus was suspended for a while, that the defects might, if possible, be remedied. The lighting was renewed on the 28th March, instant, and has been continued regularly since.

I have had the honor of accompanying the deputy master and brethren, both on the former and present occasion, so that I know personally what the light *was* and *is*. No report was made at the former time, because of the expected improvement of the arrangement; but it now becomes my duty to report on such matters regarding the lamp as properly fall within my province.

Being on board the yacht off Dungeness, on the night of the 20th instant, about 21½ miles from the South Foreland, the weather being rainy and the sky covered with clouds, we could see, when the sun went down, the high light illuminated and appearing as a faint star. I could not perceive the low light; but proceeding eastward, the low light gradually became visible, and the high light increased in brightness. When about S.W. by S., the yacht approached the lights more directly, then went eastward again, and after a while turned and proceeded towards Dover; so that the observations were made through about one-fourth of the horizon, and at very different distances from the South Foreland. From the time the upper light was first seen until the last, it remained visible and *steady*, (with the exceptions to be mentioned immediately,) and much superior to the lower light when that also came in view. The exceptions were as follows: At times the high light fell off, and once appeared almost out, when the lower light underwent no such change. This effect had been anticipated, and was due to the following cause: The upright bars of the lantern windows and the dioptric apparatus are much broader than the electric light, the latter being, indeed, not more than one-sixth of an inch in horizontal width; hence they throw deep and rather sharp shadows. By taking the bearings of these beforehand, it was found at sea that the falling off of the light *coincided* with these shadows, and hence the above exceptions. The evil occurs in part with the central oil lamp, and is in some light-houses partly remedied by causing the window bars and astragals to incline from the perpendicular, and therefore out of the plane of refraction. Other remedies, in addition to this, are applicable in the case of the electric light, and in the present instance the effect is lessened by the use of a small reflector at the lamp, close to and behind the light. The light was at all times white, or even blue occasionally, in comparison with the low light, which appeared yellow or reddish.

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* Philosophical Transactions, 1832, p. 231, Faraday.

The next day I examined the light-house and apparatus, both by day and night. The magneto-electric machines, steam-engines, and steam condenser were generally as at the last visit. In respect of the *commutator*, it had worn very little. The application of a file to the surface of one wheel had removed about the thirteenth of an inch of metal since the apparatus was first erected, there remaining about 1½ inches still ready for consumption in like manner, if needed. During the day time I compared the intensity of the light with that of the sun, *i. e.*, it was placed before and by the side of the sun, and both looked at through dark glasses. its light was as bright as that of the sun, but the sun was not at its brightest, and was only seen at intervals between clouds.

In the lantern there was now but one electric lamp in place, two others, however, being on the wire rails ready for change of lamp at any moment. The magneto-electric machines were set in action, and the lamps were manipulated with, both by day and night, to my entire satisfaction. When the steam-engines were ready for action, the machines could be set in motion, and the current evolved within the space of half a minute. The lamp could then be lighted in an instant, and if it were required to put out and displace that lamp and replace it by another, the operation could easily be performed by one person within 10 or 15 seconds. The light may be considered as at its full intensity at once, though it was reported to me as growing up in power until about four o'clock in the morning—an effect probably due to the continued recurring inductive action in the cores and coils of the revolving apparatus.

The place of the light in respect of the dioptric apparatus is exceedingly well retained, even more so than in the case of a lamp flame, which, though its base be fixed, varies in its height. The light itself is not that flickering, wavering, revolving light produced by the voltaic battery, but, in a sheltered atmosphere, as in the lantern, is fixed in its position; a fact of great importance in the application of small catoptric or dioptric apparatus. An important regulator of the character of the light is given by two magneto-electric coils introduced into the circuit in the latern. The light does not call for continued attention, but is often left untouched for one, two, or even three hours together. The eyes of the keepers are not affected, though the blue glasses provided for them are very pale in color, for the light is better watched by observing the *place* and *intensity* of the rays which fall here and there on the walls of the lantern, than by looking at the light itself.

Electric light. On going out to the hills around the light-house, the beauty of the light was wonderful. At a mile off the apparent streams of light issuing from the lantern were twice as long as those from the lower light-house, and apparently three or four times as bright. The horizontal plane in which they chiefly took their way made all above or below it black. The tops of the hills, the churches, and the houses, illuminated by it, were striking in their effect upon the eye.

All the reports which have come in from the surrounding light-houses, floating-lights, and pilot vessels, confirm the superiority of the upper light above the lower, though many of the reports are imperfect. Those from Dungeness are the best, and include 160 observations made between March 28 and April 16. The upper and the lower South Foreland and the Grisnez lights were either visible or invisible from the station, according to the weather. The upper South Foreland was visible first and oftenest, *i. e.*, *always* if the others were; then the Grisnez came oftenest in sight; then the lower South Foreland; but these were nearly equal. The Grisnez was sometimes in sight without the lower South Foreland, but never without the upper; and the lower South Foreland was sometimes in sight without the Grisnez. Upon the 160 observations, there were 73 on which none of the three lights were visible, 86 upon which the upper was visible, 40 upon which the lower light was visible, and 44 upon which the Grisnez was visible. When both the upper and lower lights were visible, the upper (except in four cases) is said to be twice the power of the lower; in the four cases it is called equal. There was one exception on April 3, at 10 o'clock p. m., when the upper light is stated to have *gone out*. The report does not say whether it came in again, but the weather at 11 o'clock is returned as very thick and misty. Generally the light is said to be very steady.

The keepers at the Goodwin and the South Sand Head floating-lights appear to have had a fair view of both upper and lower lights. If both were visible, the upper was much the most powerful; the upper was always visible. The lights were generally very steady; if wavering, both the upper and the lower wavered at the same time, as if the cause were in the air, not in the lights. The reports from the Gull Stream light are very poor and afford no instruction. There is no comparison or mention of the upper and lower lights.

In fulfilment of this part of my duty, I beg to state that, in my opinion, Professor Holmes has practically established the fitness and sufficiency of the magneto-electric light for light-house purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other that I have yet seen so applied, and in principle may be accumulated to any degree. Its regularity in the lantern is great, its management easy, and its care there may be confided to attentive keepers of the ordinary degree of intellect and knowledge.

There are many considerations, beyond the establishment of the fitness of the light in principle and management for light-house purposes, regarding its introduction into light-houses generally, on which I should hesitate to speak before those who are far more competent to judge of these matters than I am, were it not for the encouragement which the Brethren of the Trinity House give me, and especially as regards *this light*, in respect of a letter from Professor Holmes dated 28th April, 1857, which I considered in my letter of the 1st of May. I will, therefore, venture to enumerate some points which are *against* and others in *favor* of the light, and of a change in the present system. In the first place, the simplicity of the present system is very great compared with that of the electric light. Only two keepers are required to a light-house; they need possess no special knowledge, ordinary attention is all that is necessary; and thus failures of the light are almost impossible. In the new system, a second set of men will be required to attend the engines; and there must be amongst them one or more who understand the principle and construction of the lamp in the lantern, of the magneto-electric machines, the steam-engines, and the condensers below, and be able to make *effectively* the repairs necessary to the apparatus; or, as I think is more probable, a competent resident intelligent engineer, with his stock of tools and means, will be required.

In the next place, the expense of the new system must be large, compared to that of the present system. As *outfit*, there must be the cost of the two if not three magneto-electric machines, with the corresponding steam-engines; of the houses to contain them; of the cistern, condensers, and water apparatus, and supply associated with them; of the electric lamps in the light-houses, with their connections; and of the lodging-houses for the extra men. And in respect of *current expenditure*, additional provision must be made for the wages of the extra men, with coals and such things as are allowed them; the fuel for the engines; the supply of water; and the repairs required by the wear and tear of all the apparatus. To these causes of expense must be added the claims of the patentee. In the matter of expense for any given amount of light, I may say that the letters I have already referred to of the 28th of April and 1st of May, 1857, can scarcely be accepted as giving sufficient information. I conclude that by this time Professor Holmes is in a position to give an amended statement.

Amongst partial objections, it may be stated that the light cannot be expected to apply to *all* light-houses, or receive general adoption. I am not aware how many it might be fit for; but there are evidently some at extreme situations where it would be objectionable in its present state. An objection has, also, been made, of which I cannot see the force, namely, that the light is too bright, that it gives a false impression of the distance of the light-house, and that it blinds the eyes of the mariners to the perception of the lights on board vessels between it and them. These objections, if they have any force, must be judged by mariners themselves.

The points *in favor* of the magneto-electric light, now that its practicability has been established, are strong and clear in relation to the increase of light and the advancement of light-houses in power. In cases where the light is from lamp flames fed by oil, no increase of light at or near the focus or foci of the apparatus is possible, beyond a certain degree, because of the size of the flames; but in the electric lamp any amount of the light may be accumulated at the focus and sent abroad, at, of course, an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction, at pleasure, with the utmost facility. The enormous shadow under the light produced by the oil flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the magneto-electric lamp; all the light proceeding in that direction is turned to account. The optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in use It is probable that the system either of reflectors or refractors need no be above eighteen inches in diameter, perhaps much less, and probabl a foot high. The glass of the lantern through which the rays woul pass would then not require to be above twelve inches radius, *i. e.*, fro the light. This would allow that part of the lantern to be constructe of carved plates of glass, framed above and below, and requiring n opaque, intervening, shadow-making uprights. There appears no reaso why such a lantern should not enclose the electric lamp around seve eighths of the horizon, and yet allow of all necessary attendance o and change of the lamps. Such arrangements, however, could only b made when the lamp is (if ever) perfectly established, for they woul preclude the substitution of an oil lamp for the electric lamp, if an accident occurred to the latter.

Before concluding this report, I must bear my testimony to the perfe openness, candor, and honor of Professor Holmes. He has answere every question, concealed no weak point, explained every applied pri ciple, given every reason for a change either in this or that directio during several periods of close questioning, in a manner that was ve agreeable to one whose duty it was to search for real faults or possib objections, in respect both of the present time and the future.

M. FARADAY.

JULY 16, 1860.

The Chairman and Secretary visited the establishment of Mr. Holm at North Fleet, and saw the electric light, as shown in the regulati lamps of Monsieur Serin. The light was extinguished and lighted i stantaneously at various points, by breaking and making the contac The invention appeared to work exceedingly well. Mr. Holmes appear to be engaged in the construction of various forms of reflectors, and was suggested that he would do well to apply for advice to Sir Jo Herschel. It was stated in conversation that the electric light is be set up shortly at Dungeness. Mr. Holmes also stated that M Chance was engaged in constructing a dioptric apparatus accordi to calculations furnished in the first instance by Mr. Holmes, sub quently calculated by Mr. Chance. The apparatus is intended " throw the light where it is wanted," and each prism and angle is to specially ground for the light.

PROFESSOR WAY'S ELECTRIC LIGHT.

On the 13th of May, 1859, the following minute was made by Dr. Gladstone:

In the evening the Commissioners visited Professor Way, and saw his electric light. It is produced between a running stream of mercury and a small cup full of the same metal, the whole being comprised within a stout glass cylinder, cemented into brass work which screws on to the apparatus, so that the whole is hermetically sealed, and the volatilized mercury is condensed again in a long tube under the cup. The power is generated by a galvanic battery of forty-eight Bunsen's cells, which requires renewal every four hours, and is said to cost 1*s.* 6*d.* per hour, though were the products economised and the nitric acid regained, Mr. Way believes a saving of one-half might be effected. The light is continuous and forms a kind of cone between the jet whence the stream of mercury flows and the cup beneath. It is intensely brilliant, casts a greenish blue radiance on surrounding objects, and has a most wonderful effect on artificial colors, its constitution evidently being widely different from that of solar light. Professor Way showed that the current might be interrupted frequently in succession, and that the light which on each interruption is extinguished, re-kindles itself immediately contact is again made, and suggested that this might be used as a method of economising the force, of distinguishing between different light-houses, or for signaling. The Commissioners viewed the light, not merely from Mr. Way's laboratory and house, No. 15, Welbeck street, but also from Hinde street and the corner of Manchester Square, when its great superiority over gas light was most apparent.

Professor Way's light.

This light was again shown to the Secretary on the 29th of March, 1860, by Professor Way. The electric light had been shown that day to a scientific commission belonging to the War Office.

The light is produced in a stream of mercury flowing through slender tubes, and connected above and below with the poles of a powerful battery. By clock-work the connection can be broken and remade, and the light extinguished and relighted instantaneously. It was very powerful, and of a peculiar ash grey color, which gave a ghastly appearance to every person and thing in the room.

The light was said to reach its greatest brilliancy some time after the battery was filled, and to continue steady for a considerable time. After a certain time, when the acids are saturated, the light wanes.

One drawback to the light is that the force of the electric fluid scatters the stream of mercury into spray, and throws it against the glass within which the light is shown.

These drops of an opaque though fluid metal necessarily obscure the light, and settling on the glass interfere with its brilliancy.

When the glass is removed the mercury is changed into vapor, and becomes highly deleterious. A portable form of this light was shown. A small vessel of mercury within bronze cylinders, so constructed that by turning the apparatus the mercury is thrown back into the upper chamber.

Also a boot with a copper sole, intended to make and break the connection with a wire let into the deck of a ship, and joined to the battery below.

This light was exhibited at Oxford, and subsequently as a masthead light on board a vessel in the Solent, in July, 1860.

* * * * * * *

Experiments have been tried to illuminate a letter or figure, so as to enable the mariner to identify a light at night, but they all failed, fo when a long slit, 10 feet by 4 inches was illuminated, it appeared at an distance over two miles as a circular light.

FOG SIGNALS.

Fog signals.

We were shown a bell of 3 cwt., similar to that used at the Gunflee worked by machinery. The cost was about £240. Bells as large as 1 cwt. have been made for this purpose for the Casketts.

* * * * * *

THE TRINITY BUOY WHARF.

Trinity buoy wharf.

The Trinity yard and buoy wharf, situated on the mouth of the riv Lea, at Blackwall, comprises a space of from two to three acres.

It does not profess to be a manufacturing establishment, but rath a depot for buoys and of stores of all sorts for the use of light-hous and light-vessels.

A spare light-vessel is always at the wharf, in readiness to repla any light-vessel that might be driven from her station, and for the pu pose of undergoing the periodical repairs.

* * * * *

The average number of men in the yard (being those on shore their turn from the light-vessels) is 36; their average wages are £ 15s. per month, and they find their own provisions.

They are employed in receiving, storing, and issuing stores, includi oil, and in transporting buoys, manning the Trinity House yachts, &c

The whole of the oil for the entire service of the light-houses a light-vessels is stored in this yard. The average quantity in store 215 tons.

BUOYS.

BUOY STORE.

The arrangements for examining, replacing, and repairing the buo appeared to be very efficient.

Every buoy belonging to the Trinity Board, and there are more th 80 buoy stations in the London district alone, which extends fr North Foreland to Oxfordness, is replaced by a spare buoy every months, is brought on shore, thoroughly overhauled, repaired, and painted, and then kept in perfect readiness to return to its static either at the end of six months or on any accident happening to its co panion. A large shed is full of these buoys, painted, marked, a ready to start for their stations at a few minutes warning.

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OBJECTIONS TO IRON BUOYS.

An objection to all iron buoys is, that hitherto it has been found impossible to prevent them from rusting, and becoming liable to be mistaken for *red* buoys, whatever their original color may have been.

They are also more liable to accidents from collisions, being easily stove.

The wooden buoys are made of wainscot oak, as fir soon absorbs water.

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BUOY DISTRICTS.

England is divided into eight buoy districts. The Trinity buoy wharf supplies all the districts with new buoys, and for this purpose always has a store on hand painted with the first coat of priming; but each district has charge of its own reserve set of buoys.

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BUOY ANCHORS.

Hollow sinkers are being tried, so as to add the effect of suction to the weight of the sinkers.

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LIGHT-VESSELS.

The light-vessels remain on their stations seven years, and are then brought in and receive a thorough repair.

CABLES.

Their cables are changed every four years, and the old chains (1½ inch,) are converted into chains for the buoys.

CREWS.

The crews have no other occupations than their professional duties. Libraries are supplied to each ship.

The crew consists of eleven, of whom four come on shore every month for a month, and are employed in the storehouses at the buoy wharf.

The master and mate are in command month and month about.

Only good seamen are entered.

* * * * * * *

No boats are allowed to go alongside the light-vessels, and the men are not allowed to board any passing ship.

PROMOTION.

The men rise by seniority from the lowest rank to that of master.

SPARE STORES.

Spare stores for the light-vessels are always kept in perfect readiness, so that they can be sent off instantly when required.

OIL.

The oil is carefully tested.

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CABLES, HOW TESTED.

The 1½-inch cables for the light-vessels are tested with great care, as follows:

They are made in Wales, of the best iron, and before being received at the wharf are exposed to a strain of 40 tons. While exposed to this strain they are carefully inspected, to see if there is the slightest symptom of weakness, or permanent alteration in length. The strain is then lessened to 30 tons, and every link is repeatedly struck with heavy sledge hammers. Having stood this test, * * * selects a link haphazard in each length of 15 fathoms. This link is cut out and submitted to every possible strain by levers, so as to discover, if possible, any weakness in the welding or in the construction of the iron. It is then labelled, registered, and hung up for future reference in case of any accident to the chain of which it formed a part. A new link is sent for from Wales, and the length is stored for use. The chains are very rarely known to have parted. Each vessel has 210 fathoms. She has also a spare anchor and chain.

ANCHORS.

She rides at her station to a mushroom anchor, and the cable is hove in or veered according to the weather.

SPARE LIGHT-VESSEL.

The light-vessels are nine in number in the London district. There is only one spare light-vessel, which is substituted for any vessel under repair. As the repairs are sometimes very extensive, it might of course occur that the spare light-vessel being away, an accident to one of the light-vessels would find the Trinity Board unprepared to replace her, but under such circumstances the spare light-vessel at Yarmouth would be sent for.

PAINT.

The light-vessels are painted red. Experience proves that one-third venetian and two-thirds red lead are the best proportions for making the red paint.

BALLS.

The balls which serve to distinguish light-vessels from others during the day are made of wood, hollow and open; the straps of wood of which they are composed being painted red. They are in two parts. A collapsing ball, made of wood and canvas, is always supplied as a substitute in case of accidents.

LIGHT-HOUSE LANTERN FOR EXPERIMENTS.

A room at the top of the buildings at the buoy wharf is fitted up as the lantern of light-house, and a large revolving frame-work is placed there. When any new description of light or lamp is to be experimented on, a committee of the Elder Brethren proceed to a distance of some miles to study and compare the proposed lights or lamps with some other by which its merits are to be tested, and which is also attached to the frame. At stated and pre-arranged intervals the framework is moved, and the required comparison instituted.

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PERSONAL OBSERVATIONS ON LIGHTS.

SOUTH STACK.

Fog-signal birds.

It is on an island, under a cliff, and joined to land by a bridge. The sea birds are preserved as a natural fog-signal, and are tame. Gulls sit on the walls and close to the light-house, and scream continually. A few white rabbits sat amongst the young gulls, and seemed on terms of perfect intimacy.

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Fog-signal gun.

There is a large fog-bell *inverted*, which is rung by machinery. There are no guns used here, but guns are fired from the mountain above in thick weather every half hour, and oftener when the mails are expected; and the birds are preserved as a natural warning to ships, and have proved useful in fogs. The guns are heard in all weathers nine miles off at the Skerries. The bell never.

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THE SKERRIES.

This is built on a low island of some extent, covered with birds, mostly terns, which are preserved. No other fog-signals are used here, but mariners can determine their position by distinguishing the noise of the birds which frequent these two stations. The keeper has known fogs to last 48 hours, and a wreck has taken place on the mainland after six hours' fog.

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KYLE AKIN.

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Azimuthal condensing apparatus.

This light has a set of totally reflecting prisms, to economise the light and reflect a portion of it to seaward. Towards the sound the light is masked, all but a narrow beam, which acts as a leading light, and clears all shoals. To seaward the light is red, and is masked from dangers and from the shore. It was observed that the bars of the lantern were so placed as to stop a considerable portion of the light, and it was thought desirable that in future the lens and the lantern should be made and set up together before they are finally placed, so as to avoid such imperfection.

The keeper stated that this light gave great satisfaction, and enabled vessels to run in in bad weather, instead of remaining outside, as they formerly used to do, exposed to the heavy sea which sets in from the north. * * * * * *

RONA.

Holophotal apparatus.

* * * The reflectors have been altered so as to economise the light. The small end of the parabolic reflectors has been cut off, and a hemispherical reflector substituted; a small lens is placed so as to intercept the rays which would otherwise diverge past the edge of the reflectors. The result is said to be a very considerable improvement in the intensity of the light. * * * *

STORNOWAY.

Beacon with apparent light.

* * * Stopped opposite to the harbor light-house, and examined the "apparent light" on the rock at the entrance to the harbor. The light itself is revolving catadioptric, holophotal, on the same principal as Rona, but with fewer reflectors. * * * The peculiarity of this light is the "apparent light," which consists of a holophotal catadioptric single lamp, placed in a window at the foot of the tower so as to project a powerful beam on a mirror placed on the top of a beacon in the sea. The light is reflected to seaward, and dispersed by a lens placed in front of the mirror, so as to give the effect of a light burning on the beacon. The deception is so perfect that the fishermen will not believe that there is not a light there.

The pilot on board has often seen it, but thinks it is hardly powerful enough, though very useful.

People on shore at Stornoway stated that it was very useful. The reflector behind the light is made of zinc, and the keepers said that it was impossible to keep it as bright as silver. It was dark, and an attempt to rub it brighter failed entirely. It is not stated in Mr. Stevenson's account of the light why the reflector is made of zinc. It appears to be inferior to silver, but it is probably less expensive. * * * Made a turn to try to pick up the beacon light, but failed to see it. There was some light still in the sky, but the reflected light cannot have much power.

This light was subsequently observed by the Secretary, on a very dark night, from the steamer, leaving Stornoway. It was visible at a distance of perhaps half a mile, but the light was feeble; it seemed about equal to a single candle. There is a considerable divergence in the beam thrown by the lower reflector, for the light was seen for a considerable distance on both sides of the beacon in passing outside of it. The arrangement might, therefore, be improved considerably, but the principle is established. The beacon is illuminated by a lamp on shore, at a considerable distance, and the apparent light was actually seen at a distance sufficient to enable vessels to clear the danger.

Red light.

Observed the Cape Wrath light at 30 miles. The red and the white flashes were brilliantly visible and easily distinguished from each other. The night was very clear. The land of the cape seen in the evening on entering Stornoway.

STROMNESS.

Holophotal apparatus, peculiar form.

* * * The illuminating apparatus consists of three fixed reflectors—one "holophotal," as large as a small herring barrel, with a red glass in front showing in one direction; the other, a reflector of ordinary size, showing in the other direction; the third, a section of a lens, with a section of a reflector behind it, showing towards the harbor of Stromness, and across the channel.

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BELL ROCK.

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Red light.

The light is revolving, five reflectors on each of two faces, two red *and two* white. The red color is produced by chimneys of red glass, which appear to be much more convenient and should be less expensive than the large covers of colored glass used elsewhere.

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Edinburgh.

Admiral Hamilton and Mr. Gladstone visited the office of the Northern Commissioners, and in the evening went to the establishment of Messrs. Milne and Son, Milton House, Canongate, in company with Messrs. Thomas and David Stevenson. Here they saw a new holophotal light in action. It gave a very good light, as seen from Salisbury Crags, the distinction of the white and red colors being perfect. Amongst other explanations given by Mr. D. Stevenson in reference to the machinery at Messrs. Milnes, he stated that small lanterns are now made of cast iron, but large lanterns of gun metal, which they prefer to wrought iron. The astragals are now made to cross one another diagonally. Although a silver reflector is doubtless the best, a comparative experiment made on Inchkeith with a silver, a zinc, and a brass reflector, showed no great difference in the light reflected, except as to its color. The Northern Commissioners employ a very dark red glass, not the ruby.

JULY 28.

Among the pieces of information given by the Messrs. Stevenson, in the course of conversation, were the following: Some samples of colza oil corrode brass work, but the pure substance does not. It is not known what is the corrosive ingredient. It is proposed to employ bricks in the erection of the Butt of Lewis light-house; specimens of these bricks were exhibited, having a conchoidal fracture, and exceedingly hard. The mortar to be used is composed of sand. lime, and "mine dust," that is, scalings of iron; gneiss is considered preferable to granite for building purposes, as it does not disintegrate when exposed to the air and seawater, as many granites gradually do. It is difficult to mask a catoptric light sharply, for obvious reasons, and this constitutes one of the advantages of the dioptric system. Slate roofs have been adopted for many of the recently-built keepers' houses, at the instance of the Board of Trade, but they let in wet, and are greatly inferior to the leaden roofs, which the Northern Commissioners prefer.

JULY 29.

Visited the office of the Commissioners of Northern light-houses in Edinburgh. The secretary and several of the members were absent on their annual tour of inspection. Mr. Urquhart, and the engineer of the Commissioners, Mr. Stevenson, and his brother, were at the office. * * * Visited the establishment of Mr. Milne, and inspected a new revolving light, constructed by Mr. Milne from the designs of Mr. Stevenson, of glass manufactured in Paris, for Newfoundland. The apparatus consists of 12 holophotes, arranged on four faces. four on each of two sides to show red, with red glass chimneys, two on the remainder to show white.

The holophotal arrangement consists of a hemispherical reflector. with a lens and reflecting prisms placed in front. The lamp slides down to be cleaned, and can never be wholly removed from its frame. The reflectors lift out, but the glass remains fixed to the revolving frame. The whole rests on a series of rollers, and is moved by a small toothed wheel, working a large one on the circumference of the frame, which is larger than usual. By these arrangements Mr. Stevenson secures great steadiness of motion, and solidity. The quantity of oil consumed was stated to be considerably less than that burned in a large mechanical lamp.

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Buoy store, Granton.

The Commissioners inspected the storehouses at Granton. * * * There are four depots for buoys, namely, Granton, Corran Ferry, Campbelton, and Cromarty.

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The spare buoys, newly painted, were ranged under cover. The oil for the light-houses was stored in the casks in which it is sent to the different stations, instead of tins as used by the Trinity House. The oil is run out of the casks into stationary tins, and the empty casks are returned.

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FERN ISLAND.

Irish, Scotch, and English light-establishments compared.

* * One difference, then, in the services is that in the Scotch service, every light-house is provided with the same instruments and fittings, and comforts and conveniences. That the English lights are variously provided in various situations, and are rarely furnished with many articles, always provided in the Scotch lights, such as the call whistle. That the Irish light-houses visited are not provided with meteorological instruments or medicine chests, or lightning conductors, or libraries, or call whistles, or printed framed regulations, or uniforms for the men, or clocks, or dials, or with anything not absolutely required for keeping the light burning and the apparatus clean.

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COQUET ISLAND.

Catoptric and dioptric apparatus compared.

* * * The optical apparatus is one-half of a first-rate dioptric light, on the Fresnel system. A narrow strip of red glass on either side shows proximity to two rocks to the north and south. A dark patch on the glass masks the light from the dangers, and at the back a light shows into the roadstead from the lamp alone. This arrangement is very simple, and gives satisfaction. It illustrates the advantage of using lens lights for such situations as explained by Mr. Stevenson in his conversation with the Commissioners on this subject at Edinburgh. There is no arrangement of reflectors by which this variation in character could be so easily and so effectively given, and nothing could more clearly demonstrate the evil that must result from the position of the bar on the window at Berwick Pier light, which acts precisely as the screen acts here.

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Red light.

Mr. Kruger had frequently observed the revolving light on Flamborough Head at a considerable distance when the red flashes are not seen, but the light presents the appearance of two white flashes separated by rather a long interval from two similar flashes.

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SPURN FLOATING LIGHT.

Color of building.

Evidence.

The master has been thirty years on this station, which is within a few miles of the Spurn light-houses. He stated that in hazy or dark weather he can often see the red light-house when he cannot make out the white one at all. It seems that white is best seen in bright sunny weather, even against the sky, but that dark colors are best seen against the sky in dark or hazy weather.

Catoptric and dioptric systems.

Evidence.

The master also stated that the light on Spurn Point had been very much improved by the change, (from catoptric to dioptric,) though he was quite ignorant of the nature of the change, having never visited the light-house. He stated that the small light did not show very well, which he attributed to its proximity to the large and very powerful light beside it. The light-vessel also belongs to the London Trinity House. The crew were mostly below, and were taken by suprise, but the vessel was scrupulously clean. The light is revolving. There are four reflectors, which with the lamp are hung upon gimbles. They were very well cleaned and had fewer scratches than are usually found on the reflectors of floating lights. The lamp-lighter explained that scratches are often produced by portions of the charred wick falling on the silver. These, as he expressed it, cut like a knife, and unless removed with great care, injure the reflector. He did not think that sand could get at them at sea; he thought that salt water might, and might produce some injury. It was observed that the machinery for the revolving light worked very loosely, the cogs worked nearly out of gear by the motion of the vessel. Remarking on this, the master stated that the Elder Brethren, on their late visit, had noticed the same, but a great difficulty occurs in rectifying this, for on tightening the cogs the machine, from its small power, would fail to work, and interfere with the regular revolving of the light.

Dioptric apparatus afloat.

It seems to be well worth consideration whether small dioptric apparatus could not be substituted for catoptric on board vessels. Such a lamp as is used at the Lower Spurn land light would hardly weigh more than the apparatus hoisted by the light-ships. It could be swung on gimbles, and it might be lowered down a hollow mast like the funnel of a steamer. Salt water would not act on the glass, and unless broken to pieces the lens would be much less liable to injury than the reflectors, which seem to be more or less injured on board of all the light-vessels, and which, according to Mr. Wilkins, the manufacturer, wear out much sooner afloat than on shore.

Waves.

The master stated that his vessel rides very easily; "she has the full long sea from the German Ocean." It seems, then, that the more exposed the station the easier it is for riding in, provided the water be deep. The master from the Hebbles, far up the Humber, found a worse sea than he had ever found in his sixty voyages across the Atlantic. The master at the Bull complained more than the master at the Spurn, and the master at the Owers complained more of his station than did the master at the Seven Stones, who said that his vessel rode easily over the long seas of the Atlantic. The master at the Blackwater made a similar statement.

CROMER.

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The glass chimneys break according to the weather, sometimes three or four dozen a month. They vary in size very much; some have to be returned as useless. The reflectors are moved from their frame when cleaned. This was considered objectionable by Mr. Stevenson, who thinks that reflectors should, if possible, never be moved from their frames, to avoid any change in their position.

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HARWICH.

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Coal fires as coast lights.

The head keeper is 74 years of age, and was attached to the light when it belonged to General Rebow. He remembers the burning of coal fires at this station when he was a boy. The coals were burned in a grate, to which a pair of belows were attached. The light-keeper was exposed to all weathers, and had to poke the fire, throw on coal, and blow the bellows when necessary, all in the open air.

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GUNFLEET PILE LIGHT.

Loss of light from catoptric apparatus.

* * * The illuminating apparatus was now found in very good order. It consists of nine reflectors, with a red glass placed in front of each, fixed on a triangular frame, and revolving. On leaving the light it was observed that the red was visible all around. This gives a good measure for the divergence and loss of light inseparable from the use of parabolic reflectors, and shows the value of the lens used in some Scotch light-houses.

Experiment.

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NORTH FORELAND.

The tower is in process of strengthening, previous to the placing of a new and enlarged and a dioptric light. The present apparatus consists of eighteen reflectors placed on the outside of a curve in two rows, each lamp and reflector having a separate iron pillar as a stand. This arrangement is different from any yet seen. The reflectors are in excellent order, and apparently very old. There were marks of old injuries nearly obliterated by careful cleaning. Each lamp has a long meta chimney leading to the ventilator in the top. There is a tube for condensing water, but never used. A coal fire was originally burned o this tower. It was then raised and the present apparatus placed on it The interior of the tower was then used for a dwelling. The two keepers now occupy two neat dwellings at the foot of the tower, and whe the new light is placed the tower is to remain empty. The keeper see Grisnez and Calais on fine nights; he has seen Dunkerque once. O that night there was a severe thunder storm, and the light appeare as three lights, one above the other. Grisnez and Calais had the sam appearance. The keeper had observed the electric light while exhibite at the South Foreland; he was not favorably placed for seeing it. H said it was flickering. There is a sufficiency of evidence given by witnesses besides the personal observation of the Commission to prove tha the light was far superior in brilliancy to any now exhibited on th coast.

PERSONAL OBSERVATIONS.

October 19, 1859.

Admiral Hamilton, Mr. Graves, Mr. Gladstone, and the secretary, travelled from London to Paris.

The captain of the steamer stated that in foggy weather he steams by the sound of a bell placed on Boulogne pier, and that the sound is quite sufficient to enable him to take the bearings and proceed under full steam. * * * * * *

Paris, *October* 20.

France.

* * * An appointment was made at 3 p. m., at the establishment of the Commission des Phares, Quais du Billy, No. 56. At the hour agreed on the Commission accordingly met Mons. Degrand and Mons. Reynaud, and were shown the museum and other objects of interest.

The establishment consists of a lofty tower, placed on a rising ground facing the Champ de Mars, with a number of buildings and workshops, &c., attached. On the top of the tower is a lantern, from which experiments are tried. The position of the experimental light-house is so chosen as to command a clear range of 1, 2, 8, 12 miles, as may be desired.

Electric light.

The Commission were shown some experiments now making on the electric light.

The machine is a modification of that used by Mr. Holmes at the South Foreland. In consists of eight sets of horse-shoe magnets, placed on the circumference of a long wheel, of the diameter of about four feet, instead of two wheels of a diameter of about eight feet, as used at the South Foreland. The magnets pass close to iron disks in the core of the wheel, and induce currents, which are conveyed along wires to the carbon points where the light is produced. The wheel is turned by a small steam engine; but it might be made to revolve by any other sufficient mechanical power. One difference in the two machines is, that in this the currents are alternate; whereas, in Holmes's, they are made continuous, by a complicated arrangement on the axis of the wheels, which reverses the poles.

It was stated that the alteration of the currents produced no sensible difference in the light, and none was observed by the Commission.

The light was exhibited in a large darkened room, and its intensity was remarkable.

Tested against an Argand lamp, it was found to be equal to ninety-four burners. With a square lens of cast glass, and Holmes's charcoal points, it was estimated at 55,000; with the improved charcoal points, and a much larger ground glass, at 220,000; with a red glass interposed it was reduced to 1,030. (Mons. Degrand stated that the red, as compared with white, improved as the distance increased.) And it was stated that the best lens, with the most powerful oil lamp, was only estimated at from 80 to 90. The light varied considerably as the charcoal points wore away; it flickered, and occasionally went away altogether for an instant. This imperfection seemed to be caused by the charcoal; and if that could be remedied, either by the use of Professor Way's stream of mercury, or by any other means, the electric light produced by revolving magnets might be introduced into light-houses.

The intensity of the light was tested by looking at shadows projected by it on a screen of whitened glass placed at a distance of about twenty yards, and by comparing these with shadows thrown by a lamp placed at a distance of a few feet, or a few inches, as the case might be. The figures given are the result of a calculation founded on the distances of the lights compared from the glass screen, and cannot be taken as exact, though they express the difference roughly.

The museum consists of obselete methods of illumination, and improvements now adopted or projected.

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All light-houses of any importance in France are now fitted with lenses, as it is considered beyond all question that lenses are superior to reflectors. All lights are under one superintendence, and one man is mainly responsible for their management.

There are no independent local authorities as in England, and the system must be uniform. It remains to be seen whether the system works well.

The Commission were extremely gratified with the establishment, and with the politeness of the gentlemen who have charge of it.

It was stated that a fog-signal, consisting of a bell placed in the focus of a reflector built of masonry, is about to be tried.

OCTOBER 21.

The Commission met Mons. Reynaud and Mons. Degrand at the establishment of Mons. Le Peante, manufacturer of light-house apparatus. The lenses are ground in rings on wheels which revolve horizontally, and the required angle is obtained by arms which are fixed to the axle, and have certain cushions at the end, by means of which the prisms are reduced with sand. The final polish is given by hand with rouge. The glass was remarkable for its purity. The angles are all calculated to throw a parallel ray horizontally, and in the case of a light placed high, the panels are slightly inclined, so as to throw the rays downwards to the horizon.

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Measure of light.

In the course of conversation, the engineers stated that the light produced in the French light-houses was more than that produced in English light-houses of the same order, *because the consumption of oil per hour was greater.* This conclusion can only be just if the oil is *advantageously* consumed. It was also stated that the flame of a lamp properly trimmed is larger and brighter than the flame of the same kind of lamp as used in the English light-houses, according to the personal observation of Mons. Reynaud when in England. It was also stated that the light at Grisnez is by no means one of the first excellence, though it has been repeatedly praised by English mariners in their evidence as one of the best French light-houses. This may arise (according to Mons. Reynaud) from the comparison with the light on the opposite coast, (Dungeness,) which is not one of the best in England. The keepers are generally said to be old soldiers, who take a great interest and pride in their light-houses. There is an intelligent officer, generally an engineer, within reach of almost every light-house in France, charged with the superintendence of the light, and the whole system is under one man, residing in Paris, who is a member of a council (Ponts and

Chaussees) which forms a department of the government. In short, so far as the frame of the system goes, it appears to be peculiarly well adapted for securing efficient and uniform lighting. The buoyage of of the coast is in like manner systematized, but it has not been carried out. "They are now about to improve that branch of the service."

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BORDEAUX.

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Oral evidence.

Captain Charles Baker stated that, in his opinion, after four years' experience, the French lights were far superior to the English lights in brilliancy, but are not nearly so well placed; that is to say, they are not generally far enough to seaward.

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Red light.

Captain Baker's opinion is, therefore, formed on a frequent comparison of French dioptric lights with an English fixed catoptric in good order, and his testimony confirms the rest of the evidence, and is favorable to dioptric lights. With reference to red lights, Captain Baker says, that in hazy weather he has seen the red flash of the light-house at Pontillac, when the white light at the same place, and that at Terre Negre (a light-house nearer to him) were not visible. Captain Baker has traded on the north coast of Spain, and thinks these lights equal to the French, and superior to the English. He also thinks that lights placed near high land are often obscured by the condensation of fogs near the land.

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CAP FERRET.

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Instruction of keepers.

The lamp is a mechanical pumping lamp. The guardian explained that he had been carefully instructed in all that pertained to the machinery; that he had been required to take it to pieces, and set it up again, before he was entrusted with the care of the light. He showed his manner of levelling the burner with spirit levels, and of adjusting the lamp in the focus of the lens, by means of a string attached to a point on the framework; but there was no contrivance for setting the lens or the lamp, so as to throw the light downwards to the horizon. It is manifest, therefore, that here, as elsewhere, a considerable portion of the light must be thrown upwards above the horizon and lost. If the lens were set to throw a horizontal beam, the light would pass above the horizon at the height of the light-house; but as the light is seen at the distance of a few miles, the beam must have a considerable divergence, and that must be as great upwards as downwards; consequently, the greater part of the light is thrown on the clouds.

Direction of beam.

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The keeper on guard is allowed an arm-chair, but no books. Arm-chairs are forbidden in Great Britain, and books are provided.

BIARRITZ.

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Photometry.

On returning to the hotel, tested the light with the dark prism from the window, distant about a mile. A wax candle, distant 21 feet, gave

Direction of beam.

4.20. light-house flash 3.50. fixed light 2.80. At about half a mile inland the light was still brighter, and threw strong shadows from the trees on the road. As this point was *above* the light-house, and considerably *above* the level of the sea, it is evident that here, as elsewhere, the greater portion of the light is thrown upwards, and never reaches the sea, while nearly one-half is thrown over the land, where it is not wanted at all. A small reflector, fixed inside the lenses on the land side, would be some economy, and could be placed without any difficulty.

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FARO DE YECLDO.

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The apparatus is third class dioptric, fixed, with three flashes, produced by a system of revolving cylindrical prisms, made in Paris by Le Paute, the period of revolution ½ minute. The lamp is mechanical, and has two wicks. About one-fifth of the light is lost on the hill behind the house, and, though this light is about 500 or 600 feet above the sea, it is set to throw a horizontal beam. This method of throwing a flash has not been adopted in any English light-house that has been visited, and the result is satisfactory, for the light with two wicks was clearly seen at Biarritz, distant many miles.

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MALAKOFF.

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Catoptric red light.

The light is alternately red and bright, produced by three lamps in the focus of three large parabolic reflectors of cast copper, with galvanized silver. These were very dim, badly cleaned, and inferior in every respect to the worst reflectors seen in England. Their diameter is three feet, or rather more. The variation in color is produced by two screens of red glass, which revolve horizontally on arms at right angles to an upright axle. On the top is a screen of metal, which masks the upper light when the two lower reflectors show bright. The upper reflector has a red glass chimney. *Two* bright lights are considered equal to *three* red; but, according to the account of this light given by Captain Baker, the three red lights are better in hazy weather than the two bright. This light is intended to be a leading light when seen in one with the light at Terre Negre, and is built of wood, as the banks are constantly changing, and it may be necessary to move it.

Red light.

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TOUR DE BALENE.

See *ante* Needles. Color of building.

Observed, in crossing, a beacon tower built on a reef; it was colored in horizontal stripes red and black, with a white stripe close to the water. It was remarked that this produced the effect of a boat under sail with the sky showing underneath, proving the advantage of dark colors for objects intended to be seen against the sea or sky. A white light-house seen against the sky was not nearly so distinct as a neighboring church steeple colored black, as a sailing mark. The light was grey, and the sky covered with clouds.

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Below the lantern is a room with a spare lamp ready for use, and a bed for a guardian. This room is wainscotted with flowered oak, and is extremely handsome. It was subsequently stated by Mons. Reynaud, that he thought a little ornament of great practical use, as it makes the men more careful and more proud of their work. The lantern is also paved with colored marble, and slabs of the same material line the walls to the height of about six feet. The guardian explained that this was intended to prevent dust. Ornament.

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NOVEMBER 5.

Called on Mons. Reynaud, and finding that he was at the Atelier des Phares, followed him there; found a commission of members of the Government and scientific bodies engaged in an examination of the electric light.

Electric light. Mons. Reynaud stated they had succeeded in increasing the power of the light, so as nearly to double its intensity, and that, by dividing the machine into two parts, they had avoided the danger of extinction. The experiment under trial appeared to be a comparison between a single Argand burner, a four-wick light-house oil lamp, with a lens of the first order used to produce a flash, and the electric light in the focus of a cast lens on the new system for producing a fixed light; that is to say, 1st, the light used in a single reflector; 2d, the most powerful light that is now produced in light-houses on the dioptric system, involving a first cost of about £1,000 for apparatus, and a cost of 875 gallons of oil per year for fuel; 3d, the electric light, in an apparatus about the size of a hat, costing about £20 or £30, intended to cast a horizontal disk of light, and produced at the cost of the motive power of the engine, wear and tear of the machine, and cost of engineer.

The superiority of the electric light was beyond all comparison. According to the calculation of the engineers, the figures were, at the former experiment—

Argand burner, 1.
First order flash, 80 to 90.
Electric light, 94.
Electric light, cast glass flash, 55,000.
Do. first order flash, 220,000.
Do. doubled (2,) 440,000.
Do. fixed light, small apparatus, costing £20 or £30, figures not given, but the light so intense as to be painful to the eyes, and to obliterate the shadow cast by the first order flash with an oil lamp of four wicks placed near it and at the same distance. The light was steady. A report will probably be given, and should be obtained, if possible.

Motive power. It does not appear that steam power is necessary to move the machine which produces the current of electricity. A weight and a system of wheels would probably give sufficient power and velocity. If this can be accomplished, the electric light seems to be far superior to any other artificial light known.

TUESDAY, NOVEMBER 8.

Electric light. Observed the harbor light Boulogne, Grisnez, and South Foreland, at about 6 a. m., day breaking. The stars were nearly all invisible in the light, consequently the South Foreland electric light, fixed light

Observation.

apparatus, was then, at a distance of twenty-nine miles, superior i brilliancy to the stars. The fishermen all consider the new light a improvement, and remark that the color is *blue*. The sailors on boa the steamer remarked that they see the electric light about seven mil further than the other in thick, hazy weather.

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CAP DE LA HEVE.

Measure of light.

Two light-houses, very handsome, connected by a well-built row o dwellings. A permanent bazaar is established in the lower story. First-class dioptric, fixed.

Fresnel's upper and lower mirrors. Pumps for oil, very clean and in good order.

There were five keepers. The head keeper kept no night watch, but visited the houses occasionally. The oil is measured every hour. The consumption of oil appears to be considered as the measure of efficiency, and any keeper would be blamed as having neglected his duty if the consumption had not reached the required figure during his watch.

The light-houses are of the same height. Their being in one was said to mark the position of some shoal.

This is said to be the site of the earliest light-house in France. A coal fire was burnt here till 1790.

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IRELAND.—THE HOOK.

The illuminating apparatus is catoptric with twenty-one burners.

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The chimneys are broken at the rate of about 150 to 200 in the year

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Consumption of oil.

Examined the oil account to see if there was any great differenc between the expenditures in the different years. 1856, 812 gallons; 1857 812 gallons; 1858, 823 gallons.

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CALAIS.

Ornament.

The Commissioners visited the light-house at Calais. The tower is handsome building, the entrance paved with black and white marb slabs forming patterns, and ornamented with busts of Fresnel a Beautemps Beaupre. All the metal work of the stairs was beautiful polished.

Building.

The tower has no floors; it is 57 metres high, and is ascended by a cor screw stair. The keeper's room and the light-room were well furnishe and the lantern surrounded with slabs of colored marble, polished. T building in this respect is similar to the Tour de Baleine, and there no light-house in the United Kingdom in which there is so much orn ment.

Apparatus.

The illuminating apparatus is dioptric, first order, fixed, with a flas similar in plan to the small light at St. Sebastian, in Spain. A fixed lig apparatus with a series of three upright plano-cylindrical lenses rev ving outside. The effect is to produce a fixed steady light, of the fi power attained by the use of such apparatus, darkened for a short period, and the dark interval succeeded by a brilliant flash.

Observations.

The light was observed on the following evening from the South Foreland upper light, and was considered to be very powerful, though less brilliant than the light at Grisnez, as seen from the same spot on the same night. The keeper at the South Foreland agreed in the opinion formed from this observation.

The same observation was made from Dover by the members of the Commission, and the same conclusion arrived at.

It was also remarked from Dover, that some of the flashes from Calais were brighter than others. (See letter from the Astronomer Royal on this point, dated June 25, 1860, which contains his remarks as to the French trip, and account of his subsequent proceedings at North and South Foreland.)

The lantern bars are upright, so are the divisions in the bands of glass. There are mirrors on the landward side, but it was remarked that these were not so well polished as similar mirrors in England.

The lamp has four wicks. The whole was in remarkably good order. The keeper stated that he cleaned the glass apparatus with spirits of wine and chamois leather.

Direction of beam.

On examining the placing of the apparatus, it appeared that the central bands and the upper prisms were well placed with reference to the light, but that nearly if not quite all the light reflected by the lower prisms is lost on the sky.

The Astronomer Royal was requested to report on this and the other lights visited.

Flame. See drawing.

In the evening the Commissioners returned, and the dimensions of the flame were accurately taken, with a view to comparison with flames elsewhere. It was better and steadier than any flame seen in England.

Serious injury by birds.

It was remarked that the lantern was surrounded with a net of wire, and its use was exemplified by a museum of stuffed birds, all of which had been caught, or had killed themselves at this light. These included many rare small birds, a bittern, some large cormorants, and a swan.

The keeper stated that he was occupied in cleaning the glass when the swan flew against the lantern, just above his head. It broke the glass, and injured the lens so much that it cost some 3,000 or 4,000 francs to repair the damage. The man considered that the force was sufficient to have killed him, if he had not been seated at his work.

Ventilation.

The superintendent of the district, Monsieur de Lanois, accompanied the Commissioners in the evening and explained to them a system of ventilation of his own invention, which has been adopted in several French first-class lights. It consists of tubes, which are intended by the inventor to conduct cold air to the lamp down the same chimney in which the column of hot air ascends.

The Commissioners were unable to ascertain that these currents were actually descending, and cannot understand why they should, but the lamp certainly burned well and very steadily.

Pressed glass.

The two lights at the South Foreland were observed from the French coast that same evening. The upper one, that is the dioptric, was decidedly the brighter of the two. It was the opinion of the Commissioners that the Point de Walde light did not appear so bright when viewed from Calais as one of the third order should have appeared.

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GRISNEZ.

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It was found to consist of an apparatus of the same description that at the Start; sixteen faces of lenses revolving, seven rows of me curial curved glass mirrors above and four below; but inside the revol ing portion of the apparatus, and on the landward side, two large meta lic reflectors are placed.

Direction of beam.

On examining the position of the apparatus, the horizon was high 1½ inches, but on examining the mirrors they were all found to be set sc as to throw their reflected beams on the sea.

The keeper stated that he set them without any instrument, by the horizon itself; he also pointed out the height of the flame, which was about the same as that used at Calais.

Observations by Dr. Gladstone.

According to sketches made by Dr. Gladstone at the time, the image of the sea horizon, as reflected from the upper mirrors, generally cuts the flame in a plane considerably higher above the burner than was the case with the upper reflectors at Calais, and thus a larger quantity of light is thrown by them upon the sea, and, perhaps, also upon the horizon. Again, the image of the sea horizon, as reflected from the lower mirrors, generally cuts a very luminous portion of the flame, and does not impinge upon the burner itself, as was found to be the case in many other light-houses. Thus both the upper and lower series of reflectors are most efficiently adjusted. The lamp, also, was found to be perfectly central, and the metallic reflectors were better polished than is usual in France. The lenses on the whole were well made, the annular segments especially being much better than at the Start.

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The reason, therefore, for the favorable mention of Grisnez appears sufficiently manifest. The flame and the optical apparatus are properly set with reference to each other and to the horizon, and the flame is of the right size for illuminating an angle extending from the horizon to within a short distance of the light-house.

Start and Grisnez.

Whereas at the Start the mirrors are set so as to throw nearly all their reflected light on the sky, there are no mirrors on the landward side, and the flame produced is so low that nearly the whole of it is thrown on the sky by the lenses.

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SOUTH FORELAND.

Compared the position of the image formed by the lenses. The flame was also compared with the drawing made at Calais, and it was found to be less steady.

Flame.

It had more sharp points; it was lower, and, generally, it appeared t be a worse flame. There are but three wicks used.

The observation made from the "Vivid" on the last occasion wa accounted for, as also the remarks of the captain of the Dover steamer

Direction of beam.

The sea near Dover is illuminated by the narrow points of the uppe part of the flame, and the horizon and the parts of the sea near it b the lower and brighter portions. No light at all falls on the sea below a point opposite to the base of the lower light-house; none at all at th edge of the cliff. The experiment inside was verified by walking to the two points last named.

Setting prisms.

The keeper stated that the lower prisms had been carefully set to throw a level beam very lately, by placing a red ball of about an inch diameter on the lamp, and looking through each prism in turn along a spirit level outside till the ball was seen.

The result of this is, that the best of the light must be thrown here, as elsewhere, to the geometrical and not to the visible horizon, the elevation of the light being 372 feet, and the sea horizon distant 25 miles. The prisms are set to throw a beam from the place occupied by the red ball, at a height of more than 700 feet *above* a vessel on the horizon, while the mirrors at Grisnez are set by the keeper without any instrument, to throw their beams to the visible horizon itself, and on the sea below the horizon.

Divergence of electric light.

Now it is sufficiently evident that the flame placed in a dioptric apparatus of this size must be of certain dimensions to cover a certain portion of the sea, namely, about four inches, to reach in this case from the horizon (on which the electric light was seen from Boulogne) to near the place from which the electric light was seen from the Calais steamer. It was then sufficiently intense to cast a marked shadow on one hand from the other. It was also stated by the keeper that the electric light was not more than one-eighth of an inch in length, and that half an inch from point to point of the carbons extinguished it. The light was equally well seen in all directions, so it could not have been placed out of the central focus, and it remained to be explained how it had been made visible over such an angle. It was previously remarked that two small mirrors were placed on either side of the light, ostensibly to clear the bars, but it seems that as these mirrors have a certain height as well as breadth, they and they only were the cause of this divergence.

Plane reflector experiment.

To try this, a common mirror was placed behind the flame of the oil lamp, and the keeper was directed to slope it downwards and move it about. The result was, as had been anticipated, that an observer placed in a field within fifty yards of the light-house saw a brilliant light from the lens and lower prisms, when he could before only see the stray light reflected on the roof of the lantern.

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Astronomer Royal.

The Astronomer Royal stated that he had pointed out to Mr. Chance the defects which he had observed in the illuminating apparatus at Whitby, and that he and Mr. Chance were agreed as to the best method of remedying these defects, namely, by setting the lamp lower, so as to suit the position of the prisms, which now throw their light too high, and then lowering the central band of the lens to suit the new position of the lamp, cutting off so much of the central band as may be necessary from the lower portion, and supplying the gap caused at its upper edge with a new zone, if required.

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ST. CATHERINE'S HEAD.

He confirmed the remarks of the Secretary made after his visit, August 14th. In addition, he paid particular attention to the illuminating apparatus and lamp. The apparatus bears the name of Wilkins and the date 1840. The lenticular zones are of poor glass, from Newcastle; the prismatic zones are of much better glass, of French manufacture. The ce tral bands bring the horizon of the sea to about 0.75 inch above t wicks of the lamp, but some of them bring it 1.1 inch above, and othe only 0.65 inch. The keeper stated very circumstantially the height the flame as ordinarily burnt. The bright body of flame extends (says) to a height of from 2¼ to 2½ inches, and he raises or depresses t wicks till he obtains all the three circular flames of the same height, that the flame is even at top instead of being tapering. By keeping t passages clean he prevents the formation of points of flame. T strongest part of the flame is stated by him to extend from half an in above the wicks to 1½ inch. The lenses, therefore, are fairly placed, b some of the lenticular segments do not agree in focus with the centr lens, and there are irregularities in their grinding.

In order to see the horizon in the lowest prismatic zone of the upp series, it was necessary to look two inches above the farther edge of th lamp; to see it in the second, a smaller elevation was necessary, and s on, till with the seventh zone the horizon was seen in a line with th edge of the lamp. The line of the horizon as reflected from the six highe prisms cut the top of the lamp. From the lower series of prismati zones the image of the horizon was only seen by glancing a little on on side of the nearer edge of the lamp. They were evidently, therefore, o little or no value for sending the light to the horizon or sea.

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THE NEEDLES.

In addition to the remarks of the Secretary on August 15th, it may be recorded that the distinction between the red and white beams is made sharper by the placing of sheets of red glass (like horses' blinkers) at the junction of the two colors and radially to the lamp; nevertheless, the keeper has heard that in passing from the one beam into the other an orange light is perceptible from on board ship. Three wicks are burnt, but orders have been given to burn four in future, but they have not been executed yet. * * * * The illuminating apparatus is by Sautter, and was erected in 1858.

Fog.

The glass is very good, and the optical parts are very regularly made. The horizon is brought by the lenticular portions to 0.75 inch above the lamp, the flame extending, according to the keeper's statement, 2.5 or 3 inches, with a good body of light. The upper series of prisms exhibits the same phenomena as that at St. Catherine's Head, but to a smaller extent, the line from the horizon as reflected, in most of them, cutting the lamp itself. The lower series also resembles that at St. Catherine's Head in its position with reference to the flame. Thus, although this light is placed at no great distance above the sea level, the reflectors are so placed as to throw the light too high. During the first part of the visit the fog bell was being rung, but it required attention, as it stopped occasionally. The keeper said that some attempts had been made to set it right, but hitherto with only partial success; he sees the bell sometimes vibrate farther than at other times. It ought to ring for an hour and a half without being touched. The keeper said there was much fog about the present position of the light-house, but far less than on the cliff where the previous house stood; indeed, he has known a dense fog to last there for three weeks. There was one enveloping the upper part at the time when the above statement was made.

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MEETINGS AT NORTH FORELAND AND WHITBY.

NORTH FORELAND.

August 2.

Visit to North Foreland, with representatives of the Light-house Boards, &c., and the Astronomer Royal.

Admiral Hamilton, Mr. Gladstone, Captain Ryder, and the Secretary met. They were accompanied by the Astronomer Royal. They were met by a deputation of the Elder Brethren of the Trinity House, consisting of the Deputy Master, Admiral Gordon, Captain Bayly, Captain Close, and Captain Weller, who were accompanied by their scientific adviser, Professor Faraday.

They were met by Mr. Thomas Stevenson, who attended on the part of the Commissioners of Northern Light-houses; by Sir James Dombrain, Captain Roberts, and Mr. Halpin, who attended on the part of the Ballast Board of Dublin; by Monsieur Sautter, the maker of the optical portion of the apparatus, who had come from Paris; and by Mr. James Chance, the maker of the optical portion of the apparatus at Whitby, who came from Birmingham, and by Mr. Wilkins.

The Astronomer Royal pointed out to the gentlemen present the defects which he had observed, the lamp being lit, and as many of the party as possible being within the optical apparatus, and in the lantern, where they could best hear what was said.

The lamp was subsequently extinguished and the burner removed, two cross strings were fixed in the apparatus to indicate its centre, and a wire placed on the axis of the instrument. Monsieur Sautter proceeded to show the method which he considered to be effectual for exhibiting the qualities of his apparatus, and contended that it was properly and accurately placed, so that the best part of the flame illuminated the horizon.

Direction of beam.

The burner was then replaced, and it was remarked that the position of the horizon seemed to vary from that formerly observed. Mr. Wilkins stated that the lamp had been lowered one-eighth of an inch, within the last three days. The distance from the horizon of the image formed in the place of the flame to the brass-work of the apparatus was measured on a bit of ground glass, and compared with the drawing made on a previous occasion, and the card sent by the keeper, at the request of the Commission, which shows the place of the sun at sunrise to correspond with the position of the horizon as marked in the drawing. The difference between the present and the former position of the burner, according to these observations, was found to correspond with the statement of Mr. Wilkins.

The effect of the change made is to improve the position of the lamp with reference to the prisms, and to injure it in a corresponding degree with reference to the lens, but, as the flame at this light-house has a considerable height, this alteration does not materially affect the amount of light thrown by the lens on the horizon.

The question, then, for consideration is, if any, or what alteration should be made in this apparatus as now placed.

Whether to lower the lamp still more, so as to throw the light from the prisms still lower, and to lower the lens till it occupies its former position with reference to the flame, or to raise the lamp to its former position, and alter the prisms as suggested by Monsieur Sautter, or to make some other alteration, or to leave the apparatus as it is.

It was remarked that the shoulder of this chimney produced a dark line in the light of the lamp, as viewed from outside the apparatus, corresponding exactly to the image of the horizon.

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WHITBY.

Angular shoulder of chimney.

Admiral Hamilton and the Secretary went to Whitby, and met Professor Faraday at York. The minute of the observation made at the Point of Ayre, on the image formed by a reflector, was read to Professor Faraday, as also the minute of the visit to the North Foreland.

The drawings made at the North and South Foreland and at Grisnez were also shown to the Professor, and sundry photographs.

Professor Faraday.

On arriving at Whitby, Professor Faraday, accompanied by the Secretary and Mr. Halpin, visited the two light-houses, made such observations as could be made in the short time available at the north light-house, and examined the lamps at both, after they were lit.

The general impression arrived at seemed to be that the account given by the Astronomer Royal in his letter to the chairman was confirmed by these observations.

Professor Faraday will in all probability report his views on this subject to the Elder Brethren of the Trinity House.

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Dr. Gladstone, on the part of the Commissioners, pointed out what appeared to be the defects in the light-house apparatus, and his account of the meeting is subjoined.

It appeared in the north light-house—

Defects.

1st. That the lamp flame was inferior to others seen elsewhere, though much better than some.

2d. That the lamp was slightly, about one-quarter of an inch, out of place.

3d. That the whole apparatus sloped towards the sea, which defect is in favor of the prisms.

4th. That there are no mirrors on the landward side, and, consequently, that about one-half of the light produced is lost entirely.

5th. That the image of the horizon is formed a little too high by the refracting bands, but not in such a degree as to make the defect important, especially if a better flame were introduced.

6th. That the image of the horizon formed by the upper prisms falls rather too far forward, but not in such a degree as to make the light inefficient at a distance.

7th. That the image of the horizon formed by the lower prism falls too low, below the edge of the burner, so as to throw nearly, if not quite, all the light which falls to the lower prisms upwards above the horizon, except in the direction of the other light-house, where there is a short panel in which the prisms are generally well adjusted, though not all.

8th. That the metal chimney above the flame is too short below the first opening, because, on stopping that opening and altering the damper, the flame was very much improved.

9th. That the form of the chimney was very defective, in that it has a sharp shoulder, which materially interferes with the direction of the light.

It appeared to some of the gentlemen present that in spite of the observations made from within, light would in reality be seen in all parts of the apparatus from the sea. It was decided to test that point by the manner proposed by Captain Ryder.

External observation.

The keeper was instructed to cover up the refracting band at a preconcerted signal, and on returning to Whitby the party embarked on board the Trinity House yacht and proceeded to sea. On covering the lens, it was manifest that no light radiating directly from the lamp was to be seen in the lower prisms, but that a weak reflected light, that from the inside of the lantern or from some other source, was barely seen through a telescope.

It appeared to some of the gentlemen that the light would be seen at a greater distance; the vessel, therefore, ran some distance to sea, when the experiment was repeated, and with the same result.

Result.

It appeared, then, to be proved that the observations made from within were confirmed by those made from without.

Where the light had appeared to be thrown too high it was found to be invisible from the sea.

Where it appeared to be properly directed, it was seen from a distance.

At the south light-house similar observations were made inside. (*See* Dr. Gladstone's remarks.)

It was observed from the sea that the light did not appear as a continuous line when viewed through the telescope, but as a broken line, proving that some parts of the apparatus are not properly set for the existing lamp.

The Chairman requested Mr. Chance to write to the Trinity House, suggesting the alterations which, as he thinks, should be made in this apparatus.

Professor Faraday will make his report to the Trinity House, and it is proposed to request that copies of these documents may be furnished to the Commissioners.

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One of the harbor lights at Whitby was visited. There are three reflectors, placed in a tower, with gas-light flames.

The chimneys are of green glass and peculiar in their form.

The effect of the bulging shoulder, though good as regards the transmission of the rays, is bad as regards the production of light. The lights from the sea both showed green and appeared efficient, but the polish of the reflector in this, as in other cases, was inferior to that of reflectors in Trinity House, and similar light-houses.

The following is the account of Dr. Gladstone:

Dr. Gladstone's account.

Having discussed some optical questions, and the Astronomer Royal's letter relating to the Whitby lights, the party proceeded to the lights in question. These are set on two white towers, with the usual dwellings on a cliff; they are of the same altitude, viz., 240 feet above the sea level, and are 252 yards apart. The northern tower was first entered. The illuminating apparatus was found to be first-class catadioptric, illuminating rather more than half the circle, without mirrors at the back, manufactured by Messrs. Chance.

Mr. Masselin, who had superintended the fixing of the apparatus on the site, tested the position of the lamp by means of the cross string, and found it one-eighth of an inch too high, according to Fresnel's rule;

and only one-sixteenth of an inch out of the centre. From the interi
of the apparatus Dr. Gladstone then examined the relation of the diffe
ent parts to the horizon and sea, and explained to the Deputy Maste
Professor Faraday, Mr. Stevenson, and others, what were considered t
be errors of adjustment. The line of the horizon, as seen through th
central lenticular zones, comes just one inch above the lamp in the cas
of three of the panels, but 1.3 inch in a small panel to the south, and a
high as 1.4 inch in the remaining panel.

There was no apparent cause for this discrepancy in the setting, no
could Mr. Masselin offer any explanation. The upper and lower le
ticular segments generally agreed tolerably closely with the centr
lens of the same panel, but in some instances they differed widely.

When the lamp was lighted subsequently, its flame was found to b
good for a height of about two inches, so that only three of the pane
were well set for it, and had it been one-eighth of an inch lower (a
cording to Fresnel's rule) so much good light would have been los
while even as at present fixed, the lenticular zones could send litt
light to a steamer that happened to be passing at some distance, an
gave an image three inches above the lamp, or to smaller vessels th
were still nearer to the shore.

Of the upper series of prisms, the lower reflectors were evident
adjusted for the focal planes decided on by Fresnel, but the highe
three or four directed their light too much towards the sky. Of t
lower series of prisms, the reflectors had their focal planes so low th
nothing but sky was seen in them through the place where the ma
body of flame is. It was difficult to detemine the position of the fo
of these reflectors, on account of the irregularity of the curved su
faces, and the numerous striæ in the glass.

The color of the glass was considered very good, but it did not appe
to be so free from blemishes as the French. The astragals of the la
tern are slanting, but those of the apparatus itself are vertical.

The party then proceeded to the southern tower, and found the a
rangements of the lantern and apparatus similar to those already de
cribed, with the addition of silvered reflectors on the land side, whi
showed a good polish. The line of the horizon in the central lens
instead of being 1.1 inch above the lamp, as Fresnel desires, varied in t
five panels from 1.4 to 1.5 inch, while the image of a passing ship ca
3.2 inch above the lamp. To increase the mischievous action of t
adjustment, it is the square shoulder of the lamp glass that is tra
ersed by the horizontal line, and the lamp gives a singularly poor fla
The keeper termed it a 2½ inch flame, but he reckoned from the met
to the tips of the points. Reckoning from the commencement of t
yellow part, which was 0.5 of an inch above the metal, to the top
the undivided luminous mass, it only amounted to 1.0 inch, and scarce
that for the outer ring; so that in reality the sea, even at the horizo
was being illuminated only by the irregular tongues of flame, so far
least as the central lenticular bands are concerned. When the fla
was improved, (as will be presently described,) the body of fla
reached scarcely two inches above the metal lamp, and the tongu
rose at the highest to 3.5 inches, so that even then the best part of t
light was lost. The remarks made on the prismatic zones of the oth
light-house apply equally in this case.

The lamp, as in the other house, has three wicks. It is not considered an overflow lamp; nevertheless, there is an overflow of about one-fourth of the oil consumed. M. Sautter stated the French practice to be to cause three or four times the amount of oil actually burnt to overflow. The lamp glass expanded very perceptibly from the bottom to the shoulder, which was nearly square. When placed in position with its top entering the iron chimney it could not be made perpendicular. There was an opening and deflector in the iron chimney at the height of 2 feet 11 inches, another at the height of 6 feet, and a third still higher. In order to test the effect of a longer continuous chimney, Professor Faraday covered the lower opening with paper, which instantly produced more draft, evidencing itself by a depression and a greater whiteness of the flame. By turning up the wicks and regulating the damper, it was now found that a considerably higher flame could be maintained. On removing the paper, this flame started up into long yellow smoky peaks, showing that more oil was being supplied than could then be completely consumed. When the six feet continuous chimney was lengthened, by covering the opening at that altitude also, a further improvement of the flame, slight indeed, but evident, was effected.

During the course of this experiment it had been discovered, by looking from the gallery and adjoining buildings, that a good light was shining from the lamp in the northern tower, through the lower reflectors, in the direction of the horizon, and a better light still in the direction of the sea, while little light was proceeding towards the sky. Before going to the northern light-house to ascertain the cause of this, Dr. Gladstone re-entered the lantern, and observed the image of the northern tower in the lower series of reflectors through the flame then burning. In the lowest reflector the gallery was just visible; in the second and third, from the bottom, the middle of the lantern; and in the fourth and fifth, the upper part of it; while the sixth and highest was obscured by a bar. The party then returned to the northern tower, and found that the small panel of lower reflectors, through which the light had been seen from the southern tower, is adjusted differently to the others, and has, in fact, its focal planes in the anterior portion of the flame.

When standing on the gallery of this tower, a little light could be seen in the lowest reflector of the lower series of the southern lighthouse; on ascending a ladder, it became more luminous, and as the ascent was continued, light made its appearance successively in the second, third, fourth, and fifth reflectors, and at the top of the tower. The fifth was the most luminous of all. Thus, in both these instances, the practical test confirmed the observations made within the lantern, and showed that the panel of lower prisms was in the one instance set in such a manner as to be of great service, and in the other so as to be useless.

On attempting to rotate the apparatus in the north tower, it was found that it had become fixed by the sinking of the whole table on one side, caused, no doubt, by the optical apparatus pressing with nearly all its weight on that half of the table.

Mr. Chance undertook to suggest to the Commission such means as, on full consideration, should appear to him the most feasible for correcting these errors of *adjustment*.

Distinction. Red light, two lights.

In the evening the Commissioners and others of the party were received on board the "Irene," and steamed past the sunken reef, which is marked by the two lights being in one, and within which the northern light shines red. As they advanced towards the front of the cliff on which the lights stand, they observed that the northern maintained, except for a minute or two, a very decided superiority over the southern light. At a preconcerted signal from the yacht, the keeper in the northern house covered up the lenticular portion of his apparatus, when a great diminution of light was manifest, and the telescope revealed that whilst copious rays were proceeding from the upper series of reflectors, a very faint light was alone visible in the lower series. The steamer then proceeded to a distance of what was estimated by the commander to be between four and five miles from the shore, when the signal was repeated with precisely the same results, even when the light was viewed from the top of the paddle-boxes, a position nearly equivalent to the horizon. As the yacht approached Whitby, in returning, it was observed that in the southern light it was only the lowest of the lower series of reflectors that were giving any available rays, and that the whole light was cut across the middle by a dark band, suggesting the idea of the central lenticular zone throwing no light whatever upon that part of the sea.

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WHITBY.

The Commissioners proceeded to the light-houses, and several positions were selected, distant about 500 yards from the light-house, from which to view the effect of the changes which had been made.

Experiments.

In the evening the Commissioners viewed the light from three different positions, panels being brought in succession opposite the points of observation. One position was selected as coinciding with the direction of the horizon, another above it, and a third considerably below it.

Result.

A very marked difference was observed in the panels. At the highest position, one gave decidedly less light than the others; at the lowest position, the same panel gave a great deal more; at the level of the horizon, it was very difficult to discover any difference.

It seemed, then, to be proved that the light thrown above the horizon may be advantageously brought lower, so as to illuminate the sea near the light-house, without injuring the efficiency of the light as seen from the most distant point of the horizon.

OCTOBER 13.

Adjustment.

The Commissioners again visited the light, and witnessed the method pursued by Mr. Chance in adjusting some of the prisms.

Method of internal observation.

A pole with a white cross board fixed at some distance and graduated, so that a line drawn from the centre of each prism to the horizon should cut the lower edge of the board. An observer behind the burner within the apparatus looked over a scale placed on the burner through the prism to be adjusted towards the white board, and a workman moved the portion of the prism with wedges until the white board was seen in the required direction.

The prism which had been cast loose in the brass frame was then fixed with plaster of Paris, and each prism in turn was so adjusted. *Other panels* had been by the same process adjusted—some to throw the centre of the beam of light to the geometrical horizon, (that is considerably above the visible horizon,) others to points within the visible horizon.

In the evening the Commission embarked on board a steamer provided by the Trinity House, and proceeded to observe the results of the arrangements from the sea.

Experiment.

The north light had been left as it was found by the Commission on a former occasion for comparison. It was then pronounced to be somewhat superior to the south light. It was now manifestly inferior when viewed from a distance of a few miles. From the greatest distance reached the difference was hardly perceptible. The difference between the panels which were brought successively opposite to the position of the steamer was in like manner hardly perceptible at the great distance, but well marked from the nearer position.

The central band of lenses was covered, and the same series of experiments repeated with the prisms alone.

The amount of light thrown by these was remarkable. It was thought by some of the gentlemen present that the south light with the prisms alone was nearly as brilliant in comparison with the north light as it was previous to the alterations with its full power.

See Professor Faraday's report.

Professor Faraday took full notes of all the proceedings; and it was suggested that the Commission would do well to apply to the Elder Brethren for a copy of any report which he may make, and for their sanction to its publication in the Appendix.

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MINE HEAD, IRELAND.

Visited Mine Head to inspect the light-house, and to ascertain whether the evil effects of any means had been adopted by the Ballast Board for counteracting placing a dioptric apparatus, constructed to throw a level beam on an elevated site.

Mr. Halpin, the superintendent of light-houses, met the Commission at Mine Head.

Apparatus.

According to the return of the Ballast Board, this light was erected in 1851, and the apparatus then placed in it is now in use. It is dioptric, first order, "made by Wilkins, of London," and its elevation is 285 feet.

The light was previously visited by members of the Commission on September 20, 1859. In addition to the observations then made, it was remarked that the frame-work on which the illuminating apparatus stands is of wood, a number of strong beams placed around the edge of the platform, instead of the single metal pillar or metal frame which generally supports such apparatus. It was stated by Mr. Halpin that this was intended to be temporary, but no change has been made since the light was placed, nine years ago.

The frame-work appeared to be firm and strong, and the apparatus level. It was also remarked that there were no reflectors in the blank space corresponding to the land. With reference to the placing of the burner in the apparatus, it was remarked that observations taken from within could be verified by observations from the shore at points to the eastward and westward at greater or less distances, and a spot was selected from which to view the light subsequently.

Drawing.

A drawing was then made, full size, showing the plan of the burner (obtained by pressing a sheet of paper on it,) the size of the flame, and the position of the horizon of the image formed by the refracting portion of the apparatus, and the directions in which the horizon was seen in the catadioptric prisms, both above and below. It appeared that the flame was small, produced by three wicks, in a fountain lamp similar to the lamp, burner, and flame at the Start; and that the burner was well placed for the refracting panels. It seemed that the burner had been *raised* so as to counteract the effect of the elevated position of the light; but that the upper and lower prisms had *not* been adjusted to correspond, and, consequently, that nearly all their light was thrown above the horizon. Their position was worse than that of the prisms at Whitby, when they were first seen by the Astronomer Royal and by the Commissioners. The horizon was seen in the upper prisms in a direction corresponding nearly with the edge of the burner nearest to the prism, while in the lower prisms it was seen in a direction corresponding with the inner edge of the inner wick, so that the light was masked.

Direction of beam.

As the sun neared the horizon the images formed by the different parts of the apparatus in their respective foci confirmed these observations. The image formed by the refracting panels was on the metal of the burner, and rose as the sun descended. At the same moment the images formed by the lower prisms corresponded with the *near edge* of the burner, and fell below the edge, and descended as the sun approached the horizon.

Experiment Sunlight.

The images formed by the upper prisms met at a point near the top of the flame, and the rays there crossed each other, and illuminated a sheet of paper on the surface of the burner; but as the sun got lower, the light approached the edge of the burner, the point where the image of the horizon is formed.

The sun was obscured by clouds shortly before it set, so the actual position of the horizon could not be determined by this test; but the observation so far entirely confirmed those previously made in the manner already described.

Internal observations.

The Commission, accompanied by the officers of the Ballast Board, walked to a rising ground in a field, distant about three hundred yards from the light-house, and it appeared by eye observations, and by looking through a telescope, that no light was showing in the prisms, either above or below. It appeared to the superintendent to be otherwise. It appeared to his vision that, in spite of the observations made inside, light was seen in all the lower prisms, and in most of the upper ones also. A light-house keeper was accordingly despatched with orders to cover up the "central panel." It appeared to the Commission that the man had misunderstood the order, and that he had covered the *large* central zone only without covering the refracting prisms, for two spots of light could be seen with a dark space between; and the man and the cloth could be distinguished with the telescope, showing against the sky.

External observations.

Experiment.

It appeared to be otherwise to the superintendent, who still thought that the light seen proceeded from the upper and lower prisms.

Captain Robarts was accordingly requested to proceed to the light-house and see the experiment carried out. He did so; and it became evident to all present that no light, except a faint reflected light, could be seen in any of the upper or lower prisms.

Result.

In this case, then, there can be no doubt that the upper and lower prisms are, for all practical purposes, almost useless, for want of adjustment, for three methods of observations lead to the same conclusion.

Remedy proposed.

The prisms could either be adjusted by moving them in their frames, or by raising the whole upper frame till the image of the horizon appears at the proper place. If this latter course be followed, it will be necessary to make some provision for raising the lower prisms, either by cutting off part of the lower refracting panel, as was suggested by Mr. Chance elsewhere, or by some other method; or the upper prisms might be raised all together, and the lower prisms moved in their frames. It would be better to lower the burner, with reference to the refracting panels, about an eighth of an inch, for the burner now intercepts a considerable portion of the light which should fall on the lower portion of the refractors. But if this be done, it will be necessary to increase the size of the flame materially, for there is nothing to spare at present.

At all events, this light should be adjusted as soon as possible; and if the light-house authorities desire to carry out experiments such as those tried by the Trinity House at Whitby, the position is in every respect peculiarly favorable for the purpose.

A portion of the upper prisms is masked by the eclipsing shade when open.

DUNGARVON.

Direction of beam.

It was remarked that the light at the entrance to Dungarvon was seen from the hill at a point considerably higher than Mine Head, probably more than 300 feet above the sea. It seemed probable that the image formed by the apparatus was high, and it was decided to visit the light.

NOVEMBER 3.

Drawing.

The same party visited the light. It is called third order, and 52 feet above the level of the sea, the apparatus being of the same pattern as that at Mine Head, but without lower prisms, and smaller. Two wicks only are used, with a fountain lamp. A drawing was made similar to that made at Mine Head, and these two show plainly the effect produced by placing an apparatus constructed for one situation in another; that is to say, the result of placing a highly scientific instrument, such as a dioptric apparatus is, without mature consideration of the use to which it is to be put, and without giving directions or information to guide the manufacturer in its construction. The apparatus at Mine Head wants adjustment, not because it is ill-made, but because it is placed 285 feet above the sea. The apparatus at Dungarvon wants nothing, unless it be a better flame, *not* because it is better made, but because it is placed 230 feet *lower*.

Cause of defect. Elevation.

Internal observation.

The horizon was seen in the upper prisms in the direction of the *farthest* edge of the burner, instead of the *nearest*, and, consequently, nearly all the light of the lamp is thrown by the prisms on the sea, and to a point where vessels pass into the harbor near the light-house.

Result.

The horizon of the image formed by the lenticular zones is high, as was anticipated; but if the flame is maintained at the proper height, it is not too high. If the flame be allowed to burn low, the lenses might become of little use; but the prisms would always show light so long as the lamp is burning; and this apparatus, being placed at the elevation for which it was made, is efficient as it came from the maker, and without adjustment.

The bars of the lanterns of both these lights are upright, instead of diagonal, and there are no reflectors on the landward side. The lamps in both are fountain lamps: one wick is suppressed in each, and the flames of both lamps were far inferior to flames seen elsewhere.

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VISIT TO BIRMINGHAM.

Dr. Gladstone's minute.
Manufactory of apparatus.

On the 3d and 4th December, Captain Ryder, Dr. Gladstone, and the Secretary, accompanied by the Astronomer Royal, witnessed some experiments at Messrs. Chance's, near Birmingham. On the 4th they were joined by Mr. Thomas Stevenson.

Experiments Flame.

The experiments had been instituted by Mr. James Chance, with a view to apply to the lenses the same principle of rigorous adjustment which had already been applied with success to the reflecting portions of the apparatus, and at the same time to determine at what height above the burner the focus should be placed. The means of performing the experiments had been seen and approved by Professor Faraday.

Arrangements. Apparatus.

The arrangement was as follows: Near one end of a long dark shed was placed a four-wick moderator lamp, with a good slanting-shouldered glass chimney, and a metallic chimney with damper as in an ordinary lantern. This lamp could be raised or lowered at will with great precision. At the proper distance in front of the lamp was erected a series of lenticular bands, such as are employed in a first-order dioptric apparatus. Before these again were sliding shutters, so that the light which had traversed any one of these lenticular bands might be stopped or allowed to pass beyond. On the wall, at the further end of the dark shed, at a distance of about thirty-six yards, was a very large sheet of paper, which received the light through the dioptric arrangement. In front of this sheet was a thin horizontal arm moving along an upright, which was graduated with marks answering to the heights of the centres of the different lenticular bands.

External observations,

When the lamp was raised to zero on the scale annexed to it, the top of the burner was precisely on a level with the centre of the central lenticular band, and with the corresponding mark on the upright against the sheet of paper. When it was lowered, say 28 *m.*, it is evident that rays proceeding from points 28 *m.* above the burner, and passing through the centre of the central band, should strike the paper against the corresponding mark; and that this was actually the case was proved by placing a small gas jet at the same mark, and viewing it through the central lens across the edge of the apparatus devised by Professor Faraday for such purposes, when the Whitby lights were under discussion. It is evident, also, that if, when the lamp is in the aforesaid position, the brightest section of the flame is at the height of 28 *m.* above the burner, the brightest portion of light thrown on the paper will coincide with the mark that corresponded with the centre of the central band; supposing, of course, that any disturbing rays from the upper or lower bands are cut off by the sliding shutters. If, however, the brightest section of the flame is higher than 28 *m.*, the brightest

Internal observations.

Professor Faraday's instrument.

Experiment.

portion of the luminous image on the paper will be below the said mark, and, conversely, if lower in the flame, higher in the image. But the lamp being susceptible of elevation or depression, it was easy to move it till the brightest part of the light fell on the paper at the central mark. Nor was there any great difficulty in determining this. Simple observation at a distance, the effect on a secondary shadow thrown across the paper, and Mr. Stevenson's photometer, all led to the same conclusion, and different observers agreed in their judgments. By this means the following points were determined:

Mr. Stevenson's photometer.

Results.

1st. That as the flame increases the section of greatest luminosity rises. With a low flame, but such as was seen at the Start or Mine Head, the brightest portion was only 18 *m.* above the burner; with a better flame it was 20 *m.*; and with the best that was obtained during the experiments it rose to 24 *m.* This flame presented considerable body, and might be taken as a very good specimen of what is found in an English first order dioptric apparatus, but was believed to be inferior to what is maintained in many Scotch lights, and was certainly smaller than what had been seen by the Commissioners at Calais and other places in France. It is possible, therefore, that in these best flames, the brightest portion is really 28 *m.* above the burner, the height decided on by Fresnel for the focus of the lens; but it is beyond question that, where in the English light-houses the focus has that position, the brightest portion of the light is ordinarily sent to the sky. Where the dip of the horizon is not taken into consideration, this error of adjustment is aggravated, as in the South Whitby light, where the focus being 35 *m.* above the burner, must have been above the most luminous part of the best known flame, supposing such had been burned in it.

2d. That the section of greatest luminosity in a flame of this description is practically confined within narrow limits. There was no difficulty in determining it to one millimetre.

Besides the amount of oil consumed, the height to which the several wicks are turned up, the form of the lamp glass, and the character of the draught, must all have their influence on the height of this section of greatest intensity.

Chromatic aberration.

Observations were made on the different upper and lower lenticular bands, by means similar to those already described. It was not so easy to determine the position of the greatest brightness in the images thrown on the paper by rays that traversed these lenticular segments, as they exhibited the prismatic colors, but the whitest part, which was about equally removed from the red and the blue, was assumed as such. This chromatic aberration was greater as the lenticular segment examined was further from the central band, and it was more apparent in the lower than in the upper series. The following conclusions were arrived at:

1st. Supposing that the foci of the upper and lower lenticular bands coincide with the focus of the central band, it does not follow that the brightest section of the flame, as regards each of them, also coincides with the brightest section as regards the central band. In fact, the brightest section of the flame, as regards the lowest bands, was found to cut the vertical axis of the flame at a higher point than had been previously determined for the central band.

Proposed remedy.

2d. On account of this, and because when the section of maximum intensity for the central band is near the burner (say 20 *m.*,) a portion of the light that should fall on the lowest bands is cut off by the burner itself, Mr. Chance proposes that the foci of the lower bands should not be taken at the same point as the focus of the central band, but that they should be treated much in the same way as the lower reflectors are treated, viz., that some point, a little above the burner and in front of the vertical axis of the flame, should be taken as the point of intersection of the axis of pencils of rays proceeding to these lower lenticular bands; but it is evident that this is of less importance in a high flame than in a low flame.

3d. As the chromatic dispersion of the upper and lower bands is in the reverse order, that is to say, the red rays are sent upwards by the upper bands and downwards by the lower, and the converse holds good for the blue rays, the two series of bands may be so adjusted that the chromatic images produced by them should overlap and neutralize one another, producing throughout white light, or an approach thereto. This could be only very partially shown in the actual experiment, as the distance at which the paper was placed was too short to admit of much overlapping.

4th. Though the color due to this chromatic aberration may be thus disposed of, the dispersion itself must always remain, when lenses of the kind now in use are employed, and this may be a matter worthy of attention when further refinements are required.

Conclusion.

These experiments confirmed the opinion entertained by the Commissioners as to the great importance of keeping up a large consumption of oil, and therefore, a large flame, by showing that when the flame sinks, not merely is less light actually produced, but the most luminous section of the flame sinks below the focus, and is accordingly sent to the sky. Indeed, before a dioptric apparatus can be properly adjusted, it must be known what size of flame is meant to be continuously exhibited.

Charring of wick.

The man who attended the lamp showed the Commissioners the large amount of charring that took place in the inner wick after only one hour's combustion. Mr. Stevenson stated that the Scotch keepers will burn a lamp for sixteen hours without in any way trimming the wicks.

An arrangement similar to that described above was made with a pump lamp and a circular compound lens. An inverted image of the flame was thrown on the paper, which became much more definite when the light proceeding from the central portion was stopped. No measurements were taken, but the result appeared to be much the same as in the preceding experiment.

Photographs.

Photographs and measurements of the flames experimented on were taken by the Secretary.

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SUMMARY OF PERSONAL OBSERVATIONS OF THE COMMISSIONERS ON THEIR VISITS TO WHITBY LIGHT-HOUSES.

The members of the Royal Commission having concluded their visits of inspection to French, Spanish, and British light-houses, and examined carefully the system adopted in each country, and having formed an opinion of what a first-class dioptric light should be, determined to select one or more of the first-order dioptric light-houses of each of the three general light-house authorities in the United Kingdom, and then to compare them with one another and with the ideal light-house.

The light-houses selected were those at—

North Foreland and Whitby, England.

Girdleness, Scotland.

Minehead, Ireland.

The following errors and deficiencies were observed at Whitby:

I. *Glass Chimney.* [Abrupt shoulders obstruct light.]

II. *Metal Uptake.* [Not continuous; draught diminished.]

III. *Fountain Lamp.* [Very inefficient, because can never produce a high flame.]

IV. *Central Wick.* [Removal of, has diminished light.]

V. *Burner and Light.* [No means of adjusting; great difficulty of maintaining foci in right place.]

VI. *Lens.* [Error in position of one of them; portion of light misdirected and wasted.]

VII. *Lower Prisms.* [Useless; all light wasted.]

VIII. *Upper Prisms.* [Some out of adjustment; large portion of light misdirected and wasted.]

IX. *Platform.* [Out of level; light more or less misdirected.]

X. *Adjustment of Lamp Lenses and Prisms.* [No attention paid to dip; waste of best light.]

XI. *Glass.* [In some prisms streaky; light scattered and more or less wasted.]

XII. *Reflectors in Land Angle.* [None in north light-house; light in land angle wasted; reflectors in south light-house badly figured.]

XIII. *Filter.* [None; oil soiled; flow probably impeded, and brightness of flame diminished.]

XIV. *Distinctive Character of Lights.* [Two first-class dioptric light-houses an unnecessarily expensive means of distinction.]

XV. *Relative Height of the two Lights above the Sea.* [Same height above sea; impossible to know which light is open, when they are nearly in one, if the weather is thick, and the red light not easily distinguishable from the white.]

XVI. *Height of Flame of the Mechanical Lamp in South Light-house.* [Placed there in consequence of the Commissioners' first visit; very insufficiently maintained by the keeper, consequent inefficiency of light both to near and distant ships.]

XVII. *Site.* [It is questionable whether well selected.]

The two first-order dioptric lights at Whitby have lately been erected there within 258 yards of one another. The illuminating apparatus were constructed by the Messrs. Chance, of Birmingham, in 1858, and are situated at a height of 240 feet above the sea. The Whitby lights were selected by the Royal Commissioners for inspection and comparison because they were of the latest construction; because the illuminatin apparatus was constructed in England; because the construction wa undertaken by a firm which has the privilege of being aided by th mathematical talents of Mr. James Chance, (a High Wrangler of Cambridge,) whose presence ensured the recognition of scientific principle in their construction;* because their height above the sea would enabl us to ascertain whether any, and if any, what adjustment had bee made to allow for the dip. These considerations pointed out the Whitb lights as fit and proper tests, whether the knowledge of the science sea illumination, as exhibited in England by the Trinity Board in charg of the light-houses, aided by the long experience of Professor Farada (who, however, disclaims any special knowledge of optics,) and th acquirements of Mr. James Chance, had made sufficient progress an kept pace with the strides made in other cognate sciences. In short, w hoped to find that, although France might have a much greater numb of first-class dioptric lights than England has as yet fitted, (owing to h having been saddled with much fewer old-fashioned lights than Englan had when the lens system was invented,) yet that an English first-ord dioptric of late construction would prove to be not only in no way inf rior to the best French lights, but as near perfection as possible, bot as to the flame and as to construction and adjustment of illuminatin apparatus and lamp.

The Whitby lights were, therefore, exposed to the severest tests tha occurred to us, or were suggested to us, and we invited to the inspectio of them the Astronomer Royal, (who preceded us;) Mr. J. Chance, the constructor, and his foreman, Mr. Masselin; Professor Faraday, the scientific adviser of the Trinity Board; Mr. Stevenson, the Scotch Light-house engineer; Mr. Halpin, the engineer of the Ballast Board; M. Sauter, a French constructor of light-house illuminating apparatus; and the Elder Brethren of the Trinity Board, who were represented by Admiral Gordon, Captain Close, Captain Baily, Captain Nesbitt, &c.

We have little hesitation in stating that all of the above-named gentlemen on leaving Whitby would have admitted, if questioned on the subject, that the illuminating apparatus in those light-houses were faulty in most of the preceding particulars, and we regret to say, that we have reason to believe that a French first-order dioptric light is, owing to the greater height of the flame and to other minor causes, much more effective than an *English* first order dioptric light.

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*It is due to Mr. James Chance to state, that the orders given to him are simply to construct a certain well-known apparatus, (Fresnel's dioptric illuminating apparatus,) of a given size. Up to the time of the commencement of our inquiries, he had not directed his mathematical researches into investigations connected with the scientific questions bearing on the subject.

Mr. Chance was never informed of the height of a proposed light-house; and that very inferior description of lamp, the fountain, was ordered of another firm, leaving him no option in the matter.

It is due to Professor Faraday to state, that he has always disclaimed being considered an optician. It is due also to the Elder Brethren to state, that they make the same disclaimer. They appear to have placed implicit confidence in Fresnel's calculations, and supposed that his adjustments were applicable to any height of flame, and that there was no necessity for testing the adjustment of prisms and lenses after the illuminating apparatus had been erected at the light-house, or that the height of the light above the sea need be taken into account in adjusting the position of the lamp.

I. The Glass Chimney.

The glass chimney was of the usual shape supplied by the Trinity Board, and was, as stated by Mr. James Chance, *not* like the chimney supplied by his firm to the Whitby light, (with the illuminating apparatus,) the shoulder being much too abrupt. We ascertained that there was a large stock of Mr. Chance's chimneys (similar to the French chimneys) in the light-house, but the light-house keeper thought it to be his duty to expend all that were left of the old pattern before he commenced using the chimneys of the more modern and improved shape.

The shape of the shoulder has, no doubt, an effect on the draft, but whatever may be the difference of opinion as to the advantage in regard to the draft in having a gradual or an abrupt shoulder, we have ascertained quite beyond a doubt that an *abrupt* shoulder will refract the light irregularly, so that many rays will, on passing through, be deflected from the horizontal direction.

Occular proof of above statement.

Several horizontal dark lines were observed, apparently in the shoulder of the chimney, and coinciding with that portion of the flame where the image of the horizon was formed, and from which the horizon was illuminated. These dark lines pointed out that rays were intercepted which would otherwise have gone to the horizon.

Photometric proof of above statement.

Mr. Stevenson showed us the result of some very interesting experiments to ascertain the degree of intensity of the flame when seen through various sections of the lens, and we noticed a remarkable indentation in the curve, probably caused by the abrupt shoulder in the chimney.

Curve of intensity as ascertained from careful observations by three observers ascending Salisbury Crags.

Photographic proofs.

Mr. Campbell produced a photographic picture of a flame seen through a glass chimney *with an abrupt shoulder*, by which the effect of the abrupt shoulder in producing dark opaque lines was clearly shown.

M. Sauter produced photographic pictures of flames seen through the *French chimney*, in which the shoulder is very gradual, and *no* such dark lines appeared.

Mem.—Orders, it was understood, were given on the spot by the Trinity Board to substitute generally the gradual shouldered chimneys for those with abrupt shoulders.

II. Metal Chimney or Uptake.

In the first-order lights, the distance from the top of the glass chimney to the cowl is considerable, probably 12 feet at least; this space is occupied by a metal chimney, in two lengths of about 6 feet each, and the lower length is again subdivided.

The openings were suggested some time since (15 or 16 years) by Professor Faraday, and adopted by the Trinity Board, to prevent a down draught from the cowl in windy weather. Under the impressio that the *annular* opening admitted too much air, and thereby injure the draught and lowered the flame, we tested the assumption by fillin up the annular space with paper, which had a most remarkable effec The permanent flame was raised in the north light-house from abo two inches to nearly three inches, and in the south light-house from o and a half inch to more than two inches. Closing the upper openi did not have much additional good effect.

The opening may, therefore, be left to carry out Mr. Faraday's reme for down draught. This experiment showed that there was not suffcient draught—that a six feet metal chimney or uptake was ver much more effective in producing an upward draught than the thre feet tube; but it was asserted by Mr. Faraday that the beneficial effect could not be maintained unless the oil was supplied more copiously than at present by the inefficient fountain lamp universally supplied by the Trinity Board to the first order dioptric lights.

III. FOUNTAIN LAMP.

The fountain lamp universally used in dioptric lights by the English and Irish Light-house Boards consists of a reservoir of oil slightly raised above the burner. The pressure of the oil, owing to this difference of level, forces the oil through and past the wicks. We observed that the oil overflowed very languidly, and were told that if the difference of level was increased by raising the reservoir, (the most evident remedy,) the vessel that catches and retains the oil that has overflowed would become full so frequently as to inconvenience the light keepers, an argument to which we did not attach much weight or importance. We caused the level to be slightly raised, and the increased overflow had an immediate beneficial effect in raising the flame; but this method of keeping a high flame, owing to the irregularity of the supply of oil, is very inferior to the overflow lamp. The irregularity arises in the following manner: If the influx of oil in a fountain lamp is increased by the attendant, the flame immediately rises, the pipes quickly become hot, the specific gravity of the oil in the rising branch is diminished, the influx of oil is increased with great rapidity, and the flame becomes extravagantly high, smoky, and unmanageable.

The keeper at St. Catherine's (Isle of Wight) states that when the oil is thick he raises the reservoir so as to increase pressure.

A Fountain Lamp.

The level of oil in lower reservoirs is maintained, by means of a float, at just the same height as the wick.

The overflow lamps used in France and Scotland, in the first-order lights, but which, for very insufficient reasons, (see letter from Trinity House, 3d January, 1861,) have been discontinued in England, force over three times as much oil as they consume, whereas, the fountain lamp, as at present constructed, forces over less than is consumed.

The moderator and the triple or quadruple pump, worked by machinery, are the two descriptions of overflow lamps in use in France. (Th triple pump only is used in Scotland; they arè said to be equally effective.) A small alarum is fitted to them in France, which warns the keeper the instant that the overflow diminishes in rapidity.

Alarum.

Is a cup with a small hole in it, balanced by a weight. The cup is periodically filled from the overflow; when full, its weight depresses it, and rings a bell.

If the overflow ceases to pass over with sufficient quickness to fill the cup, and thus ceases to overcome the drain through the hole, the cup becomes entirely empty, and sets off the alarum.

It is of great importance that the high rate of overflow be steadily maintained, for the draught being considerable and the flame high, a failure in the oil supply is attended with the following result: The oil, instead of being passed over in proportion of three to one of the oil consumed—a proportion which, by the coolness of the oil, keeps the metal holder and wick cool,* and prevents the rapid consumption of the wick by charring—is passed over in some lower ratio, the wick becomes charred, smoke is created, effective flame is first diminished, and the light at last either extinguished by the oil, or the oil becomes so heated as probably to injure the burners, when the flame has burnt the wick down close to the top of burner. Great watchfulness is, therefore, necessary to maintain the high flame, which we observed to be universally maintainable in France and Scotland in the *overflow* lamps. With proper and constant care, when the overflow is considerable, the wick need not be trimmed throughout the night. The fountain lamp in use n England in first-order lights, if we may judge by the Whitby lights, cannot maintain anything more than a low flame, (see personal observations at North Whitby. (The flame at the south light was still ower. This difference was probably owing to a variety at the Whitby ights in the size of the supply tubes or in the draught.) There is an evident loss of a large portion of the light if a low flame is substituted for a high flame. This loss is greater than is due to the mere diminution of light produced, for if the burner and the illuminating apparatus have been adjusted to one another for Fresnel's *position* of the foci, which had reference to a very high flame, and which *position* has always been given in England, although the flames are only half the height of Fresnel's,) the section of greatest luminosity falls below the focus for parallel rays, and the strongest light is therefore sent to the sky. Again, those portions of the flame above the focal line of the lens (which are the portions lost when the flame is low are of the *utmost* importance to the the illumination of the sea between the horizon and the base of the light-house, and of *considerable* importance to illuminating the horizon also.

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The height of the centre of the section of maximum intensity was estimated by Fresnel to be 28 mm., or about 1.1 inch above the burner in a first-class dioptric. This height was not even approached at Whitby.

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*The oil in contact with the flame, by its rapid change, is sufficiently cool to prevent the wick from being charred, but the whole of the oil is sufficiently raised in temperature to prevent it becoming thick in winter. This last is an additional recommendation of the overflow lamp, compared with the fountain lamp, as at present constructed, in which the oil becomes cold and thick in frosty weather.

The great importance of a high flame is also exemplified when we consider the action of the *upper prisms.*

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It has been stated by Fresnel, and hitherto generally accepted by makers of illuminating apparatus, that the focal plane for the *lens* of a first-class dioptric should be about 1.1 inch above the burner to ensure that the focus be in the brightest part of the flame, but Fresnel, in giving this height, referred only to the high flame of a mechanical lamp. A complete series of experiments is yet wanting to ascertain which is really the brightest section of flames of different heights, as seen from the *lens* and from the *upper* and *lower* prisms. When these have been ascertained by photographic and photometric experiments, it is possible that some slight change may yet have to be made, even with high flames, in the hitherto received positions of the foci for the lens and prisms. For a fountain lamp this height should probably not exceed 14*mm.*, or 5 inches.

Fresnel places the foci for *upper* prisms in first-order lights 22*mm*. above burner, and the foci for lower prisms at points between 38*mm*. and 68*mm*. above the burner, so as to clear the burner and wick.

Other circumstances of importance must also be taken into consideration in placing the foci. It is said to be highly inconvenient to have prisms which throw out *converging* rays, because, among other matters, the practical adjustment of the prisms is much embarrassed thereby, and it is recommended by Mr. Chance to endeavor to give the prisms a slight *divergence*[†] by slightly flattening the curved side of the prisms.

This would insure all rays from luminous portions of the flame, after leaving the prism, becoming slightly divergent. Mr. Chance is still continuing his experiments on this interesting subject.

All these very important questions regarding the position of the foci depend upon the primary decision as to the relative importance of sending rays from the *brightest* portion of the flame to the *horizon*, compared with illuminating the sea within the horizon by an equal distribution of the rays through the angle.

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If paramount importance is attached to sending to the horizon the brightest rays that pass through the lens, rays from the *lower* portions of the flame as the beam is inverted *must* be wasted and sent above the horizon. If paramount importance is attached to utilizing all the rays, very few rays need be wasted, and yet, after mature consideration, the opinion will probably be unanimous that, notwithstanding the waste of rays, it is better, in the great majority of cases, whatever the loss, to ensure that the horizon shall receive the brightest rays. It must never be forgotten that one great use of light-houses is to passing ships, who deviate, perhaps, considerably from their course to sight the light, (made out perhaps 30 miles off from the mast head,) and then immediately resume their course. Any diminution in the brightness of the ray sent to the horizon would be a serious injury to such vessels.

The great and increased importance of maintaining a ***high*** flame in *thick weather* is probably not sufficiently understood by light-house keepers, and should be impressed upon them. A high flame requires constant, watchful care, and can only be maintained by an increased expenditure of oil. This accounts for the great disparity in the expenditure of oil in first-order lights in England and Ireland, when compared with the expenditure in French and Scotch lights.

[†] When a prism is found to have a more than usual amount of divergence, but yet not sufficient to cause its rejection, it should be adjusted, Mr. Chance suggests, so that the upper edge of the divergent beam goes to the horizon, otherwise, some of the rays will be unnecessarily wasted in the sky.

The Scotch and French light-house authorities insist on the maintenance of a high flame, and insist on the consumption of that amount of oil which they know by experiment is necessary to maintain a high flame. Their consumption is nearly 70 per cent. larger than the consumption in an English or Irish first-order light under the Trinity House. This very important subject requires evidently to be studied with much greater attention in the English and Irish first-order lights, all of which ought to be supplied immediately with mechanical lamps, and a certain maximum consumption per hour should be insisted upon.

Since our last visit to Whitby, on which occasion we found that the mechanical lamp had been, in consequence of our first visit, substituted at the south light-house for the fountain lamp, the north retaining the fountain, we have obtained two returns—one, the observations of passing mariners, and another a return from the Trinity House, giving the daily consumption of oil at both light-houses for many weeks. To our great surprise, we found that the mariners gave a much slighter preference to the south light over the north than had been expected, considering that with a mechanical lamp the flame can be maintained at a much greater height, although at a considerably increased consumption of oil. Our surprise at this disappointing evidence ceased when we found, on reference to the Trinity House return of consumption of oil, that the keeper in charge of the south light had, either through ignorance or intentionally, constantly consumed only the same amount of oil in the new mechanical lamp as the keeper in charge of the north light in the old fountain lamp. The average consumption [illegible] is made, remain, therefore, at the South Whitby not more than [illegible] gallons, instead of more than 700, which is consumed in Scotland and France, and the flame remain as low and therefore as inefficient as before. We found that the Elder Brethren had apparently taken no notice whatever of this ignorance or neglect on the part of the keepers at the South Whitby, and we can now understand what had already puzzled us, viz., why the mechanical lamps were condemned by the Elder Brethren many years since. There can be no doubt that a mechanical lamp is an expensive, troublesome, complicated instrument, if it is used, as at the South Whitby light, for the purpose of consuming only a small amount of oil, one gallon in seven or eight hours, and creating a flame of about one inch, which can be obtained just as well by the common fountain lamp. While it is an invaluable aid, and the benefit conferred is enormous, [illegible] developed, to consume one gallon in [illegible] and [illegible] a flame of from three to four inches.

[illegible]

The next point in [illegible] The French [illegible] and at the North Foreland [illegible] just readopted them with the mechanical lamp. If rays only originated from the outer surface of a flame, and did not pass through the flame, it might at first sight appear unnecessary to pay any attention to the central portions of the flame, but it is well known that the pencil of light passing from a flame in any given direction varies in intensity with the depth of the luminous section or portion of the flame from whence it has emanated. The external flames, like other flames, are transparent, and the light from the central wick passing through them sensibly increases the quantity of effective light. The omission of the central wick enfeebles, so to speak, the central portions of all these sections, and reduces the amount of light proceeding in all directions.

V. BURNER AND LAMP.

There was *no* means of *adjusting the height of the lamp burner, or of correcting any lateral error.*

The burner at the north light-house was one-sixteenth of an inch out laterally, and also vertically, as regards the *geometrical* horizon. It might be advisable to instruct the light keeper how to adjust the position of the lamp burner as is done in France; and the lamps ought to be fitted with the means of ready adjustment. Small screws should be placed in the framework, (as in Mr. Chance's,) from which, when two lines are stretched across, their intersection should cover the centre of the burner. The keepers should test this occasionally, and report any error, and should be exercised, when inspected, in shifting lamps. In France the mechanical lamps are replaced by the spare lamps every three weeks, to insure the pumps being kept in good working order.

VI. LENSES.

In the southernmost lens in the north light the focus of divergency, the rays from which, when collected by the lens, would pass to the horizon, was about half an inch higher in the flame than the other lenses. As the flame was at its best very low, this lens was probably of very little service. Mr. Masselin could not account for this. It arose, he thought, either from the curvature being faulty or the glass having a different refractive power; but M. Sauter suggested another reason, viz., that the workmen who ground the edges of the lens had taken too much off one edge, and in securing the lens in the frame had misplaced it. The error was so evident, that Mr. Masselin, Mr. Chance's foreman, was asked how it was that it had not attracted his attention when he was erecting it at Whitby? He stated that, although he had expressed a wish that the lanterns should be first finished, his wish was disregarded, and he was obliged to erect the illuminating apparatus while the lantern was being built; both operations being carried on under a cover, which prevented the horizon from being visible, otherwise he would have detected the erroneous lens.

VII. LOWER PRISMS.

The lower prisms sent all their rays to the sky, none to the horizon or sea. This most extraordinary fact was detected in the first place by the Astronomer Royal, and its truth was confirmed by all of us. The only prisms that sent their rays even to the geometrical horizon level were those of one section of the prisms of the north light, occupying only a very small portion of the circumference, and they could only be seen from the direction of the south light.

Mr. Chance states that this error has arisen from his having in these light-houses attempted *strictly* to carry out Fresnel's rule as to the height of the foci for the lower prisms, a rule which he now finds to be in considerable error in first-order lights, although correct for the third order.

There is no doubt that there are first-class dioptric light-houses that send rays to the sea through their lower prisms—Girdleness, for instance, in Scotland, specially examined and tested by the Astronomer Royal to ascertain this, and also all the light-houses we inspected in France. Mr. Chance assumes that this may be accounted for by their having been *practically* adjusted (without any reference to Fresnel's rule) by so fixing the lenses and prisms that the optical image of the horizon formed by each falls upon the brightest part of the flame. Mr. Chance *now*, since his attention has been drawn to it, practically adjusts all the lenses and prisms irrespective of Fresnel's rule.

It is evident that all first-order lights, and, in fact, all dioptric lights hitherto erected in the United Kingdom, should, as early as possible, be visited by competent persons, and the fact of the well or ill adjustment of all their lenses and prisms be ascertained, and any errors found corrected. The Astronomer Royal estimates that this could be effected in about two years if one person only was employed.

The Trinity yacht conveyed the Royal Commissioners at night to a distance of from four to five miles from the Whitby lights, when, by a preconcerted signal, the central lenses of the northern light were covered, and it was then satisfactorily shown to the Elder Brethren, by the aid of telescopes, that there was no light in the lower prisms. No light came through the lower prisms of the south light either.[*]

[The lower prisms at the south Whitby have now been adjusted. A very slight change in the position of the prisms was sufficient to effect this important object.]

VIII. UPPER PRISMS.

The upper prisms were sensibly out of adjustment. Mr. Chance's foreman, when seeking for the horizon in these upper prisms, by the method suggested by Mr. Campbell, our Secretary, detected some errors of adjustment in them. These prisms have since been readjusted.

IX. PLATFORM.

The platform or table was out of level. The illuminating apparatus has hitherto been placed on one central iron support. This may in course of time settle or give, which would throw out the action of the illuminating apparatus very considerably. At Girdleness the platform is supported at its circumference by a series of inclined or zigzag roads. This method of support appears greatly preferable to that by central columns. The maintenance of correct levels should be ascertained from time to time by means of a spirit level.

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[*] During the day, on looking at the south lights, lighted for the purpose, from the gallery of the north light, also from a window at its base, no light could be seen in lower prisms. It was only seen from the top of the lantern of the north light, considerably above the horizontal direction.

X. ADJUSTMENT OF LENSES AND PRISMS FOR THE HEIGHT OF LIGHT ABOVE THE SEA.

As, owing to the curvature of the earth, the visible horizon is below the geometrical horizon, the rays intended for the visible horizon ought to be dipped through that angle. This angle will increase with the height of the light-house.

Now that the glass can be made very clear, free from veins, and therefore non-divergent, and great accuracy can be attained in the shape of the prisms and lenses by the cross-action in polishing them, this angle of dip cannot be ignored without unnecessarily sending a considerable amount of light to the sky; and the higher the light-house the more light is wasted in that direction. The necessity of taking the dip into consideration is increased, if at one and the same time, as in England and Ireland, the burner has been placed with regard to the focus of the lens in the position pointed out by Fresnel, (viz., for first order dioptric, 28 *mm.* or 1.1 inch below the focus,) and the flame is, or may be expected to be, lower than the high flames created in Scotland and France. The section of intensest luminosity is only that height, (1.1 inch, above the burner,) in very high flames, and is much nearer the burner in low flames, such as those produced in England and Ireland by the fountain lamp.

The burner appears to have been placed originally at the above distance below the focus in England and Ireland, whatever may be the height of the light above the sea, and notwithstanding the use of the fountain lamp. The horizon, therefore, in such case takes the larger portion of the light that reaches it through the lens from sections having their intersection higher in the flame than the focus for parallel rays by a distance due to the dip; and as the flame is low, by the inefficiency of the lamp, the section of intensest luminosity is (owing to the latter fact) still further separated from and dropped below the portion of the flame sending light to the horizon; therefore, the necessity of taking the dip into consideration is magnified when the focus is at 1.1 inch above the burner, and the flame is low. Thus, for a lighthouse 240 feet high, at which the dip of the horizon is 16′, the focal point corresponding to the sea horizon is higher than that corresponding to the geometrical horizon by 0.16 inch, and if the focal point for the geometrical horizon is 1.1 inch above the burner, the focal points for the sea horizon will be 1.26 inch above the burner. At this height, even with the best French lights, the intensity of the light is sensibly diminished, unless the flame is at its best, and with the English lamps it is in some cases nearly lost. It is very easy to adjust the lenses and prisms in their frames in the workshop, to throw the most brilliant rays towards the visible horizon,* provided an experimental range can be obtained. Mr. Chance has now a considerable range, and a vertical board on which a line representing the visible horizon for each prism and lens is marked. A ladder is placed against the board, and the eye is placed in the proper position when any lens or prism is being adjusted. It is by no means an easy operation, except for a person accurately acquainted with optical science, to readjust the prisms after they have been erected in the light-house; and it should not be attempted, except by an optical engineer, for this evident reason, that raising or lowering the lamp has opposite effects in the lens and in the prisms, and every prism must be moved. This was effeted at the South Whitby under Mr. Chance's personal superintendence.

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* The plan proposed in Mr. Stevenson's work, viz., to cant or tilt the lens, is erroneous, as tilting the lenses only distorts the image; it does not move it in altitude. Even if tilting had the stated effect, it would be very unadvisable to give the keepers power to tilt the lenses.

But it may be asked what injury would have been done *to the illumination of the horizon*, and *to the illumination of the sea*, by neglecting the *dip*, as has been done in the United Kingdom and France, if the flame is maintained at its proper height, as it is in Scotland and France, by the use of the mechanical lamp; and this question has a direct practical bearing on the case. The readjustment of all the prisms is a serious matter. Take this case, viz: A light 240 feet above the sea as at Whitby,(an unusual height in the United Kingdom, where atmospheric difficuities, unknown in the Mediterranean, interfere to prevent the selection of great heights,) and let us suppose that the lamp there used had been the mechanical, and the flame the proper height. At the height of 240 feet the horizon is sixteen miles distant. The flame of a mechanical lamp four inches high gives a divergence of 6°.

First, the Lens.

The beam passed through the lens is inverted. Its brighest portion occupies about say 1° of the angle, the remainder being divided, the lower edge of the divergent beam will, in such a case, if the angle is 6°, and the height of the light above the sea 240 feet, strike the sea at 1,090 yards distant from the base of the light-house; within that distance no direct rays will reach the hull of a vessel through the lens. The dip due to the height of 240 feet is 16'. If the brightest beam derived from the section of intensest luminosity has a divergence of more than 32', without any sensible decrease of intensity, then the *horizon* will be illuminated by rays from the brightest portion of the flame, and will not, as far as the lens is concerned, have suffered by the light not having been dipped; but even supposing that, owing to the equable intensity of luminosity extending over a portion of the flame, sufficient in size (¼ of an inch) to enable the horizon to be lighted from the brightest part of the flame, though the light has not been dipped, it is evident that the sea within the horizon must soon begin to suffer. for there can be no doubt that the *upper* portion and not the *lower* of the beam of the greatest intensity should be directed to horizon, as in the former case the remainder of the section of greatest luminosity will illuminate the sea, instead of, as in the case of the light being undipped, going to the sky. It is the sea, then, rather than the horizon, that is most injured. as far as the lens is concerned, by neglecting the dip. At first sight we are inclined to suppose that neglecting the dip may be very injurious to the very near ships, but when a calculation is made, it is readily seen that dipping in the above case, through the angle of 16' will only light up an additional narrow strip of the sea, about 130 yards broad.

To sum up, therefore, the effect of not dipping, as far as the *lens* is concerned, when the mechanical lamp is in use, and *the flame is of the proper height*, the effect is, first, *perhaps* to slightly injure the illumination of the horizon; second, *certainly* to injure materially the illumination of sea within the horizon; and third, to exclude from direct rays a very narrow strip of the sea near the light-house.

Upper Prisms.

Neglecting the dip is a maladjustment of the prisms, and has this effect, that the light which reaches the horizon is taken from a more advanced section of the flame, reducing thereby the size of the portion of the flame which illuminates the sea, diminishing, therefore, the total light sent to the sea through each prism, and probably transferring the position of the focus for parallel rays for each prism to a less bright section of the flame.

If the lamp, supposed to be a mechanical lamp, with a high flame, is raised to dip the rays passing through the *lens* from the brightest section to the visible horizon, then the original error in the adjustment of the *upper prisms* is doubled, and great care will be requisite in deciding upon how far it is safe to raise the lamp. At Girdleness, Professor Airy, for this reason, recommended that the lamp should only be raised through half the angle of dip. In England and Ireland, until the mechanical lamp is substituted for the fountain, another element of disturbance enters into the question, and no imperfect adjustment should be attempted.

Lower Prisms.

So small in altitude is the portion of the flame which the interposition of the edge of the burner allows to send rays to the lower prisms, and so narrow, therefore, the emitted beam, and so small the divergence, that a neglect of the dip will very possibly deprive the horizon and the sea of any rays from the lower prisms, as we found to be the case at the Whitby lights, where the lower prisms sent all the rays that passed through them to the sky.

As the portion of the flame which will send rays below the horizon to the sea is that portion between the direction of the axis of parallel rays and the edge of the burner, any attempt to raise the lamp, in order to dip the brightest rays through the *lens*, unless the lower prisms are also readjusted, will probably bring the axis of parallel rays into the burner, and then immediately the lower prisms will cease to illuminate either the sea or the horizon, even if the latter had previously received some few rays.

It is right to state here that rays from the sides of the flames may still be effective.

Neglecting the dip, therefore, when the flame is high, unless the height of the light above the sea is considerable, does possibly no great harm to the effect of the *lens* at the horizon, but it diminishes the light sent through the lens to the sea, and it lessens the amount of light sent both to the horizon and the sea from the *upper prisms*, and lessens, if it does not entirely prevent, the transmission of any light to the sea, and perhaps also to the horizon through the *lower prisms*.

In the case of the electric light, where the dimensions of the luminous body is only about ⅛ of an inch, and the divergence is therefore very small, it is of the last importance that the rays should be accurately dipped and directed. In the case of the oil lamp *with a flame of 4 inches*, and a divergence of 6°, for reasons stated above, the question is comparatively of less importance, *provided always that a proper flame is maintained;* but as there is no difficulty in adjusting the lenses and risms for the given height. it should never be neglected, as careless eepers may neglect to keep a high flame. Very careful experiments o measure the intensity of different sections as seen from lenses and prisms should be made.

XI. GLASS.

We noticed that the glass of some of the prisms at Whitby was streaky and wavy. Since that glass was cast, Mr. Chance informs us he has effected a great improvement, by melting the glass in covered pots. Some glass, since produced, is quite free of streaks, and of a very good color.

XII. REFLECTORS IN LAND ANGLE.

In the North Whitby light there were no catoptric reflectors on the land side of the illuminating apparatus. There were reflectors in the south lights, but they were badly figured. This would afford a good opportunity of testing the value of the catoptric reflector. In its absence, about ¼ of the light, viz., that in the land angle, is entirely lost and wasted.

XIII. FILTER FOR OIL.

The oil is not filtered in the English light-houses. The filtration of the oil in the French light-houses is part of their judicious treatment of the science of illumination: the greatest care being taken to measure the quantity consumed in every hour, or during each watch or guard: and the great and natural anxiety of the keepers to maintain a perfect flame, precludes the possibility of the unconsumed oil that remains in the lamp in the morning, partly soiled and injured by its contact with the flame, being allowed to form part of the oil at the commencement the next night. It is therefore carefully removed, but before being returned to the general reservoir, it is necessarily carefully filtered. Filters should be introduced in all our light-houses.

XIV. DISTINCTIVE CHARACTER OF LIGHTS.

The Whitby light-houses are both of the first order, and therefore of the most expensive character. They cost, when completed, £5,256, and they will, with high flames, cost for maintenance about £800 per annum. £800 per annum, at 4 per cent., represents a capital sum of £32,000, which, added to the primary cost, viz., £5,256, makes the total cost of the light-houses £37,000. If the second light-house is unnecessary, and sufficient distinction could have been given to *one* light-house, the large sum of £18,500 has been wasted. The direction of the rock is sufficiently pointed out by the red cut-off.

XV. RELATIVE HEIGHT OF THE TWO LIGHTS ABOVE THE SEA.

The lights have been placed so as to point out the line of direction of a danger off the harbor. That two lights, if intended to be used as a leading mark to clear a danger, should be of unequal height, one being higher than the other by a number of feet, depending upon the distance of the danger and the horizon, it might have been thought an axiomatic truth in light-house engineering, and if, to gain this object, it had been found advisable to have the buildings much closer together, economy in various ways would have been studied. The reason why such light-houses should be of unequal heights is, that when of the same height, as at Inishowen, it is impossible to know, when they are slightly open, whether it is the nearest or the most distant that is to the right or left, a very important point in intricate navigation. At Whitby, the light in the north light-house turns to red when the lights are in one, but in some states of the atmosphere it is difficult to distinguish white from red.

XVI. HEIGHT OF FLAME OF THE MECHANICAL LAMP IN THE SOUTH LIGHT-HOUSE.

On our second visit we found a mechanical lamp at work in south light-house, and all the upper and lower prisms readjusted. Various experiments were tried, (see Mr. Farrady's report,) but it is necessary to observe, that the experiments cannot do justice to the mechanical lamp, for, as exhibited in the south light-house on that occasion and since, it did little credit to the principle.

The light-house keepers were inexperienced, could only succeed in burning one gallon in six or seven hours, instead of in less than five, as in Scotland, or as in France; and on the night of the sea experiments, when we were disappointed at the south light not showing to greater advantage, it was ascertained from Mr. Chance that the nature of the programme, which instead of being entirely a time programme, as was suggested, involved constant looking out for the ship's signals, and therefore frequent opening and shutting of the gallery door, injured the draft, and therefore the flame, which was not improved by the presence of additional keepers in the lantern. Mr. Chance stated that he had to change the chimney twice because it got smoky; to trim once, and that he observed the flame was, strange to say, brightest when the overflow was least, all proving that the flame was in anything but a satisfactory state.

The necessity of maintaining always a *high flame* of 4 inches, must necessitate constant watch and guard on the part of the keepers, and this again, frequent visits on the part of inspectors. In France, the inspectors have a master key, so that they can visit at unexpected moments. Commanders and lieutenants of coast guard are perhaps the persons in the United Kingdom who could most satisfactorily perform this duty.

It would be necessary for them, without any warning, to enter the light-houses, measure the height of the flame, and report it next morning, with any remarks on the watchfulness or otherwise of the keepers. They should not have the power of interfering in any other manner, or of giving any orders or instructions.

XVII. SITE.

Owing to the height (240 feet) of the lights above the sea, they are frequently obscured by clouds. It admits of considerable doubt whether one light-house, about 120 feet in height, on an outlying rock, would not have been more efficient and less expensive in the long run.

It will be seen by reference to the Astronomer Royal's report on his visit to Whitby, that he estimated the waste of the small quantity even of light that was afforded by the old fountains lamps then in use as ery considerable, owing to the various errors he alludes to, leaving only a small portion of the light, estimated by him as one-tenth, really useful. Now that a mechanical lamp has been placed in the South Whitby light-house, and all the lenses and prisms have been carefully readjusted by Mr. Chance, the light and brilliancy ought to have increased most considerably; but this desirable result awaits the proper management of the lamp, and an increased consumption of oil.

The above remarks on the errors and deficiencies at Whitby have been submitted to the Astronomer Royal, the Commissioners being most anxious neither to overstate the number of errors nor to attach too much importance to any one of them.

Professor Airy, after carefully considering them, has been pleased to state that "he believes the above statements as to the errors and deficiencies ot Whitby to be perfectly accurate."

INVESTIGATIONS PROPOSED BY DR. GLADSTONE.

PRODUCTION OF LIGHT.

1. The relative light-producing power of different oils and hydrocarbons, both liquid and gaseous, such as colza oil, olive oil, seal oil, porpoise oil, benzine, paraffine, belmontine, camphine, coal gas, oil gas, gas saturated with vapor of naphtha, in reference to the quantity burnt. Each of the combustibles must be burnt to the greatest advantage, and hence may require a particular kind of lamp.

This was done in reference to sperm and colza oil, before the change was made by the Trinity House.

2. The relative light-producing power of the lime light, as produced by hydrogen and oxygen, or by coal gas and oxygen, and with various forms of apparatus; also, with caustic lime and various compounds of lime; and, indeed, with the substitution of magnesia, alumina, or other earths in place of lime. These should be referred to some standard by which they may be compared with the combustibles mentioned in the previous paragraph.

3. Analagous experiments with electric lights. Different forms of galvanic battery, or electro-magnetic machine, different kinds of charcoal points or other material to become luminous, different forms of regulator, &c., must be considered.

4. As the power of penetrating a mist is not always directly proportional to the amount of light emitted through a clear atmosphere, the above experiments ought to be repeated in a mist.

5. The relative advantages and disadvantages of these several combustibles and means of producing light in regard to expense, tendency to smoke, effect of temperature, effect of irregular draughts, liability to explosion or other accidents, portability, room required for machinery, &c.

UTILIZATION OF LIGHT.

6. The amount of light lost in reflection from polished silver, copper, glass coated with mercury, glass covered with silver by Petitjean's process, by Leibig's process, &c. This must be determined for various angles.

Professor Potter has made some experiments with reference to th question.

7. The amount of light lost in transmission through glass of vario composition. This is a composite phenomenon, depending partly absorption, which will differ with the thickness of the glass, and part on reflection from each surface, which will differ with the angle which the ray enters the glass and the angle at which it emerges fro it. All these circumstances must be considered.

Professor Potter has also made some experiments in this direction.

8. How far the above results depend on the intensity or character the light itself.

9. Whether polarized light, such as must be produced where ligh passes through glass surfaces at high angles, is as capable of penetra ting a mist as unpolarized light is.

10. The relative value of different parts of the flame to differen pieces of optical apparatus.

This was attempted in a previous paper of mine, at least as far a the ordinary dioptric arrangement for a fixed light is concerned.

11. Whether a flame is perfectly transparent to its own rays.

Count Rumford determined that it is; but the fact recently recognized, that certain flames absorb light of the same refrangibility a they emit, would indicate that more minute experiments might show that it is not perfectly transparent.

12. The relative luminosity of different sections of a flame take horizontally and diagonally at various angles. Flames of all the different sizes and characters actually used in light-houses should b examined.

This experiment it is proposed by the Commission to perform, at leas as far as regards a first-order lamp.*

When all these questions are determined, it will probably be simpl a matter of calculation to determine the five following points:

13. The relative merits of parabolic metallic reflectors, and optica apparatus made of glass alone.

Various computations have been already given by Mr. Fresnel, Pr fessor Potter, Mr. Alan Stevenson, and others, but more complete dat are desiderated.

14. The angular limits in the vertical plane within which it is des rable to employ a lenticular arrangement; and where a system of total reflecting prisms becomes more serviceable.

15. The most advantageous form for the totally reflecting prisms.

It is possible that, as suggested by Mr. Campbell, if the surface l which the ray enters, and that by which it emerges, were at rig angles to it, it might cause a saving of light, notwithstanding t longer space of glass which the ray would then have to traverse.

16. The most advantageous position for each separate piece of optic apparatus.

The Commission have already given this matter much consideratio but the data do not yet exist for a complete determination.

17. Through how large an angle in the vertical plane the diverge

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* As Messrs. Chance performed experiments with this object, which were sub quently inspected by the Commission, they considered it unnecessary to carry c their previous intention.

beam proceeding towards the horizon from a given lamp flame, and with a given optical arrangement, may be considered practically uniform in luminosity.

18. The influence of different forms of the shoulder of the lamp glass on the direction of the emitted rays.

19. What kinds of glass are least effected by weather or sudden changes of temperature.

20. The influences of different forms of lamp glass on the draught. Lamp glasses may and do differ in having the shoulder at different heights, shoulders of different forms, or no shoulder at all, and in having cylinders uniform in width, tapering, or trumpet-shaped, and in their width and height; or they may be globular, pear-shaped, &c.

21. The influence of other parts of the apparatus on the draught, viz., the continuous metallic chimney, which may be wider or narrower, longer or shorter, straight or bent, uniform or otherwise in width, &c.; the wick holders, which may be thicker or thinner, more or less wide apart, &c.; the central button or open space, &c.

22. The best means of preventing irregularities in the supply of air, and in the rapid removal of the products of combustion during gusty weather.

23. The amount of overflow of oil which is conducive to the burning of the largest quantity of the said oil in a given lamp.

24. The most simple and trustworthy means of producing this overflow with regularity.

The French appear to have experimented much on this and the previous question.

25. How to secure the requisite strength in the astragals or other framework of the optical apparatus and lantern, with the least possible interference with the light.

26. The amount of heat rays reflected back by mirrors of various kinds. This need be considered only when the rays strike the mirror at right angles to its surface.

27. How far a flashing light has the advantage in catching the eye of an observer at a great distance, irrespective of its intensity. As this is a subjective phenomenon, it will differ with different observers.

Some experiments, now in progress by Professor Swan, which bear on this subject, are alluded to in Sir J. Hershel's evidence.

COLOR.

28. The relative space-penetrating power, either through a clear or a misty atmosphere, of rays of different refrangibility, and consequently different color.

Sir D. Brewster's observations and mine, on the Beachy Head light, and elsewhere, have to a great extent determined this. Messrs. Reynaud and Degrand have also published a paper on the power of the red ray to penetrate to great distances.

29. The particular rays transmitted by different colored glasses, and how far this is affected by heat. As the same nominal color may be produced by different means, for instance, red glass by copper or by gold, glasses of these different compositions must be examined. As the thickness of the medium or the depth of the color most materially

influences the absorption, this should be determined for various thicknesses.

This has been partially done by Sir J. Hershel, myself, and others.

30. The most efficient and easily applied means for enabling an ordinary color-blind person to determine the color of a flame seen by him at a distance.

31. How far does the different power of irradiation or diffraction cause one colored light to be more visible than another, either through clear or misty atmosphere, the intensities being equal.

32. Whether there is any subjective cause tending to the more ready perception of some particular colors.

33. Whether colored lights can be advantageously produced by bringing certain salts or other substances into the flame of the lamp; or by exposing baryta or strontia to the oxyhydrogen flame, in place of lime; or by steeping the charcoal points of the electric lamp in similar salts.

34. Whether a larger amount of colored light might be obtained by making use of a portion of a beam prismatically dispersed than by reducing it by absorbent media.*

FOG-SIGNALS.

35. The manner and degree in which fog absorbs or destroys sounds of different pitch.

36. The manner and degree in which fog absorbs or destroys sounds of different characters; for instance, a sharp sound or a prolonged sound.

37. A comparison of the various means of producing loud sounds, as to their pitch, volume, convenience, costliness, &c. The bell, gong, gun, drum, horn, whistle, &c., must be considered.

38. Whether there are any reasons existing, either in nature or in the human mind, which render more perceptible a repetition of the same sound, or some variation in note, octave, frequency, &c.

39. The influence which the height above the sea at which the sound originates has upon the distance at which it is audible in fog.

40. The influence of a back ground, such as a tower, a cliff, or a hill, in reflecting sound.

41. The best means of directing a sound in a particular direction.

42. The best means by which the direction of a sound may be approximately determined by a listener on board ship.

BUILDINGS.

43. The relative durability of different kinds of stone, slate, brick, composition, cement, metal, and other building materials, when exposed to sea water or sea spray, as well as the ordinary influences of wind, sun, and rain. The relative costliness and ease of working will depend much on the site.

44. The same in respect to different kinds of paint and other coloring materials.

45. The best form for resisting the force of the waves, the building being solid.

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* Sir David Brewster, in his reply to the scientific questions, received since this was written, suggests other means of obtaining the same object.

This was determined by Mr. Alan Stevenson to be a hyperbolic curve.

46. The best form and arrangement of piles, so as to secure the greatest strength with the least resistance to the waves.

47. The best methods for maintaining a comfortable temperature in the lantern, watch room, and keepers' houses.

48. The most convenient, trustworthy, and inexpensive methods of producing a continuous movement for revolving apparatus, working fog-signals, &c.

ALTITUDE OF LIGHT.

49. The comparative amount of interruption in the visibility of a light by the upper, middle, and lower strata of ordinary showers.

The following inquiries are of a local character:

50. The ordinary height of the sea mists at or near the proposed site.

51. The influence of hills, and other geographical characteristics of the neighborhood, on the production of clouds during prevailing winds.

52. The ordinary height at which these clouds are formed, or at which those borne by prevailing winds pass.

53. The height to which the sea spray rises at the proposed site during common gales.

54. The height to which dust rises under similar circumstances, and whether it is of a character that would attach itself to the glass of the lantern.

J. H. GLADSTONE.

The preceding list was first submitted on August 29th, with the exception of Nos. 19, 26, 34, and 49, which were added in December, 1860.

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LETTERS FROM THE ASTRONOMER ROYAL.

* * * * * * *

My observations show the importance of attending more carefully to height of lamp than has yet been done, and show that in the use of small sources (as the galvanic spark) it will be *extremely* important to be assured that the height is always the same. I have written to Faraday to ask him whether he is certain of this constancy of height.

* * * * * * *

I am, &c.,

G. B. AIRY.

Admiral W. A. B. Hamilton, &c.

Royal Observatory, Greenwich,
April 11, 1860.

My Dear Sir: On the other leaf I place excerpt of a letter which I have received from Faraday, regarding the vertical adjustment of galvanic lights. He has no fear about it, but remarks on the care which it may require.

I mentioned to you my strong objection to the entertaining of any proposal for use of glass *prisms* and lenses shaped by any process except grinding. The inconsiderate parsimony which has induced a body to contemplate the use of pressed glass for light-houses is to m totally incomprehensible. Let any one examine the straggling bea of light that are given by the sun shining through an ordinary wind glass, or let him view a complicated prospect, as seen through suc glass, and then compare them with the same things as seen throug good ground plate glass, and he will see what would be lost by su adoption, or rather, he would see *part* of what would be lost; for, believe that the accuracy of form which can be given to a pressed pie of cast glass is far below the accuracy of parallelism of the two surfa of blown or sheet glass in ordinary windows, and its error on the dir tion of a beam of light greater than that of a window glass in the sa degree; and this is in a case where the smallest error is ruinous. error of 1° in the transmission of light by a window glass produces danger, and does not make the window useless; but an error of 1° the light-house beam would make the light-house inefficient, and wou produce great dangers on the coast. And I believe that the materi proposed for use would be liable to produce even a greater angul error.

The percentage of saving which the adoption of this imperfect su stitute for ground glass would produce would be very small. Th Skerry Vore light-house cost about £80,000; others have cost fro £10,000 to £40,000. Imagine this expense, in fact, thrown away to sav £200 or £300 in the glasses. It is, in fact, a kind of economy which n one who uses spectacles would adopt in his spectacle glasses, and whic no hospitable entertainer at dinner would adopt in his dinner service.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

Extract from a letter from Professor Faraday to the Astronomer Royal, date April 9, 1860.

"As to your inquiries about the electric spark, the lamp that Prof Holmes has had constructed *practically* works well; for, being adjusted an edge or object near the light throws a shadow on a distant wall whos place does *not vary*. The keeper watches this shadow from time to time (or such a shadow,) and if there be a change corrects for it, but th compensation for a change of place in the carbons, either upper or lower, has been very good. I have no fear for the place of the magneti electric spark, provided we can secure the attention of the keepers that will not be called for more than is required by *the written regulation now*, or than was given by the keeper at the South Foreland; but i must be a good deal more than what is absolutely *necessary for an oi lamp.*

"If the electrict light should come into use, it seems to me that ther will be no difficulty in bringing both the vertical and the horizonta divergence easily under command."

ROYAL OBSERVATORY, GREENWICH,
London, S. E., April 14, 1860.

MY DEAR SIR: With this I return Mr. Campbell's excellent letter. The process which he has used at the Point of Ayre is *exactly* what I had intended to use at the South Foreland or the Start, with this modification, only, that I had intended to provide myself with two pieces of dark cotton, so that I could cover all above and all below a single prism or a single set of prisms, and could thus analyze the operation of every individual part of the optical apparatus. I think that in the extension of operations some such arrangement will be found useful.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
May 25, 1860.

MY DEAR SIR: I think it desirable to put on record my impressions derived from the examination of the Start light-house. I wish that I had done so sooner, but my time has been very closely occupied.

1. Fixed frame in which the rotating part revolves. The part of this frame which guides the axis of the rotating part is not quite vertical. The error which it produced on a two-feet plumb line was about ⅛ inch forwards or backwards, so that probably the top is in error about ¾ inch with respect to the bottom.

2. Corrections of radius of the rotating polygon. There is no error worth mention.

3. Eccentricity of lamp. The lamp is about ⅜ inch eccentric. This arises, I suppose, from the want of verticality of its pillar support, which is disreputably conspicuous to the eye. The workmanship is not good.

These errors do not in themselves produce any sensibly injurious effect with the existing large lamp, supposing it fully lighted up. (With very small lights they would be intolerable.) But in combination with the fault of lighting the lamp of which I next speak, No. 1 may produce a sensible effect.

4. Elevation of lamp flame. On examing the position of the inverted image of the W. SW. sea and sky over the lamp, as formed by the central lenses of the sections of the rotating frame, it appeared that, (with irregularities to be mentioned,) the image of the sea horizon is about 1.1 inch above the lamp rings, oftener more than less. When the lamp was lighted, as in the usual way, its outermost ring of flame was barely as high as this, or not so high. Consequently, the whole of that light is thrown into the sky, and is useless to ships. The two internal rings of flame probably send their brightest light to the sea horizon, or nearly so, and, upon the whole, their arrangement is not injudicious. Yet, considering the effect of the external ring of flame, a greater quantity of light might be sent to the horizon, and a much greater quantity on the sea generally, (including the near distance,) if the lamp were raised ¼ inch.

5. Loss of light on the unarmed sides of the light-house. On ⅜ of

the circumference, if my recollection is correct, (possibly less,) no light is shown, and the light radiating from the lamp in that direction is in no way utilized. In the circumstances of a revolving light, (as the Start,) the only method of utilizing this light appears to be to plant a spherical concave mirror, whose centre is the lamp, *in the inside* of the rotating part, *not carried by* the rotating part. When as in the Start light) the floor does not rotate, this can be done without difficulty. In some constructions I think there might be difficulty.

6. Form of the central lenses. The greater proportion (about six) of the central lenses appeared to me to be not badly shaped; the image of the sea horizon occupied pretty nearly the same place as viewed by light coming through the centre, the top, the bottom, or the sides of the lens. The foci of some fell short of the lamp centre, or beyond it; but with the large lamp this is unimportant. But there was one lens extremely bad; it produced a distortion like that of a knob of crown grass. It could never have been verified, and must be regarded as very discreditable to the maker. (This is a very advantageous specimen of what would be produced by pressed glass.) There was another, bad in a minor degree.

7. Form of the ring lenses. The curvature of the surface of the rings is exceedingly erroneous. The image of the sea horizon produced by each ring, instead of being something like a horizontal line, as it ought, is in all cases a line clinging to the circular form of the ring, so that the inner portion of the ring is usually seen bright and the outer portion dark (or vice versa.) I suspect that the rings have been ground in a spherical bowl, which would give equal curvatures in radial and tangential directions, and this would be erroneous. Mr. Chance's process, of causing the ring to rotate round the optical axis, while the transverse curvature is determined by the nature of the cross stroke of the polisher, controls perfectly the relation of the curvatures, and gives the power of impressing the proper form on both. From what I saw of a lens ring under test, and of the general processes of testing at Messrs. Chance's works, I scarcely doubt that their curvatures are quite correct. I should much like to examine them on a sea horizon.

8. Upper fixed reflectors. There are 7 by 19 fixed looking-glass reflectors, each adjustable by its separate screws. These screws do not strain the form of the glass, but only alter its general position. The mirrors are therefore subject to two examinations, one for form, the other for position. The examination for form is difficult (on account of elevation) and tedious (on account of the number;) and where these circumstances hold, many faulty mirrors will infallibly be inserted. Some of them gave the image nearly as it ought to be seen, but I was not provided with proper apparatus for the examination. Some *certainly* gave the image as it ought *not* to be seen, and some were *worthless*.

For examination of position there is provided a small apparatus based on the principle of observing the surfaces of a colored fluid in two rising ends of a horizontal tube. It is a fault of principle in this, that it adapts the reflectors to give a strictly horizontal beam; but I see no difficuty in adapting it, by a small float, to give a beam dipping to or below the sea horizon, and, with this modification, I approve of the principle; but the details of carrying out the operation of examination are barbarous. The stand which carries the glass tube ought to revolve a circle, preserving the radial position of the glass tube; yet there is o revolving radius to carry the stand in this position. The vertical anges of mirrors are in definite azimuths, and the stand ought, in sucession, to be placed opposite these. There are no marks for the purpose. he horizontal tiers are at definite heights, and the glass tube ought, in uccession, to be placed at those heights. There are no marks for the urpose. In all the adjustable machinery that I have seen, I never saw nything so bad. It is *impossible* that the adjustments can be often examined.

The whole of this system is unsatisfactory, but I suppose it will never e repeated.

I omitted to mention that some of the looking-glasses are much tarished.

9. Practical effect of these faults. It must be borne in mind that the ffect of a fault is to be estimated by its proportion to other faults to which it is added. Now, there is the primary fault of the size of the amp flame, producing a divergence in every beam of about 5°. If the aggregate of all other faults can amount to 5°, then, if the beam of ight ought to be definite in the vertical direction only, its fault is doubled; if it ought to be definite in both dimensions, its fault is quadrupled, (and at any rate its intensity is diminished to ¼.) Now, the refraction of the ring lenses is so bad that I think it likely that they do add 5° of divergence, and not improbably the reflectors do so. On the whole, I think it likely that the light-house does *not* give *half* the intensity of light which, as a large lamp light-house, it ought to give, independently of failing from want of dip of the beam of light.

If, instead of the large lamp, there were a small ball of lime, or a galvanic spark, the optical failing would be intolerable.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. Hamilton, &c.

Royal Observatory, Greenwich,
June 16, 1860.

My Dear Sir: 1. I returned late last night from the Whitby expedition. I reached Whitby on the evening of 13th, and, after being provokingly misled about the locality of the light-houses, found them, and took a partial view in the same evening till the time of lighting the lamps. On the morning of 14th I went to them in a carriage, and, as they are near the Scarborough road, I drove on to Scarborough, and thence made Hull on that evening. Yesterday, 15th, I returned by way of Lincoln. In order first to despatch unscientific business, I will mention that my son Hubert accompanied me, and was useful in the observations, as well as a comfort to myself, (indeed, I should have been unwilling to go alone,) and I therefore think it right to consider him as a chargeable assistant.

2. The two light-houses are on the edge of the high cliffs, between two and three miles S.E. of Whitby. They are about 300 yards apart, and act as leading lights for warning of a rock called the "Whitby Rock." Both are first-class fixed lights, and each gives illumination to

something more than a semi-circumference. The south light has reflectors in the blank part; the north light has none. They bear the name of Chance, in an inscription in large letters on the supporting pillar, from which, as well as from the statements of the light-house keepers, I infer that the entire light-frame was made by Chance's firm. The external lantern was made by Wilkins. The lights are at the same height, 240 feet above the sea.

3. The dioptric part of the apparatus is beautiful. The glass is of the best quality. The working is so perfectly true that in viewing the image of the horizon, and moving the eye so that it (the image) is shifted from the broad central band successively to the narrower lateral bands, there is no perceptible jump or indistinctness, every band forming its image truly and exactly in the same place. (If the same accuracy be preserved in ring lenses, as I have reason to believe from the performance of the ring which I saw under trial at Chance's works, there would not be the *smallest* degree of the clinging of the horizon to the outline of the rings, and the succession of tooth-forms, which were so offensive at the Start.) It is a most beautiful piece of work; possible only where the maker is a man of science and also a practical man.

4. The catadioptric parts are very good, but not so strikingly good as the dioptric. The veins of the glass are seen, (I could not see any in the dioptric,) and there was some difficulty in catching the image of the line of horizon so sharply. Still, there it was; and there was no difficulty in seeing that the boundary of light did move over the whole as it ought. (The horizon was not very clear, as seen by direct view.)

5. The reflectors in the south light-house did not please me. Their *general* form, I believe, is pretty correct, but the *details* of the form are bad. The image of a straight bar as seen in them is as crooked as a sheet of corrugated iron. If I could have shut up the light-house into perfect darkness, and could have put a common candle in place of the lamp, I could have judged better of the effect of the reflected light. But my impression is that the reflectors are of very little use.

6. So much for the apparatus as prepared for use in the light-house. Now I proceed to speak of its adjustment in the light-house.

7. Upon comparing the height of the image of the sea horizon with that of the metallic part of the lamps, I found that in the north light the image of sea horizon was more than 1.1 inch above the metal, and in the south light more than 1.5 inch above the metal. The height of the lamp flame was stated by the attendants at about 2.5 inches; but when the lamps were lighted, and maintained to what they considered the usual and proper height, I found that a great part of that 2.5 inches was the spikes of the flame. On examining the image of the sea horizon, with the lamps lighted, (which is by very far the best way,) the following results were obtained:

8. Dioptric part. In the north light-house, a very insignificant part of the continuous flame (with its spikes) rises above the image of the sea horizon. In the south light-house, the spikes only of the flame rise above the image of the sea horizon. In other words, scarcely any part of the light falls upon the sea, distant or near; the great mass of light is thrown to the sky.

9. Lower catadioptric part. In both light-houses an insignificant part only of the light falls on the sea; in fact, we pronounced the lower parts to be useless.

10. Upper catadioptric part. In both light-houses the useful part of the light would be nearly defined by a sloping line.

* * * * * * *

11. My impression is, that in the north light-house three-fourths of the light is absolutely thrown away, and in the south light-house nine-tenths of the light is absolutely thrown away. When, with a ruler, I covered the part of the flame which merely gave light to the sky, it was absurd to see how little was left for the useful part. The light-house keepers saw and understood it as well as myself: and my son can tell you as accurately as I can how large is the loss. It really gave me a feeling of melancholy to see the results of such exquisite workmanship entirely *annihilated* by subsequent faults in the mounting and adjustment.

12. If the lamp flames were burnt much higher, the proportion of loss would not be so great; but still the positive loss would be great.

13. To remedy the evils in this instance, and to make the lights truly efficient, the first step would be to raise the lamps about ¾ inch for the north light-house, and about 1¼ inch for the south light-house. This would make the dioptric part perfectly good; but the catadioptric parts would be made worse than they are at present. In order to correct them, the brass frames must be loosened, and their upper ends must be drawn outwards to an extent easily determined by trial. Then the whole light-house would throw a magnificent blaze on the sea.

14. I may point out two collateral proofs of the extent to which the defects of the lights have been practically experienced. The first is the introduction of reflectors into the south light-house and not into the north light-house. The explanation is, as I have stated, that the south light-house is in more faulty adjustment than the north. The second is, that sailors have made complaints that the light-house gallery cuts off the lower beams of light, and that it ought to be lowered; the explanation is, that in the fault of adjustment, all the light is thrown too high, and none is thrown low.

15. To prevent the frequency or repetition of such faults as are conspicuous in these lights, I see no course but the appointment of a competent optical engineer, who shall be responsible for the careful examination of the lights in their place and in action.

16. I have now to submit another remark to yourself and the Commission. With whom the blame of this fault of adjustment rests I do not know, but I can say with certainty that the merit of the most admirable workmanship of the glasses is Messrs. Chance's. The state of these light-houses must substantially be published; they will necessarily be connected with Messrs. Chance's names, and a great blame may be unjustly thrown upon those manufacturers. It is, in my opinion, much to be desired that a statement of the condition of the light-houses, fully embodying a recognition of the beauty of the workmanship as well as an account of the fault of adjustment, should be communicated first to Messrs. Chance. (For instance, parts of this report might be copied, beginning with article 3 and ending with 14, and also one which I am going to subjoin.) Some steps might follow, in the way either of correspondence, or of material action, or of both, which, while they would not cause a suppression of the statement which I have made, would permit it to be given in such a shape as would prevent the commission of any injustice, or the excitement of any painful feeling.

17. The further statement, which I had nearly omitted to make, is t that the engineer's work in the frame, &c., is of excellent quality, the lamp piller is firm and truly central, and all the solid work app to be of the highest order.

I am, &c.,

G. B. AIRY

Admiral W. A. B. Hamilton. &c.

Royal Observatory, Greenwich, S.E.,
June 25, 1860.

My Dear Sir: I propose in this letter to lay before you the impr sions which I have received from examination of the following fi light-houses, viz:

The High Light on the north bastion at Calais.
The Small Light of Cape de Valde.
The Light of Grisnez.
The South Foreland Light.
The North Foreland Light.

1. The High Light of Calais. The fundamental part of this light essentially similar to to those of Whitby and the Forelands—a fix light, furnished with bands of glass for the central or dioptric part, a with prismatic bands with internal total reflection for the upper a lower catadioptric parts. The glass is good, but I think not equal that at Whitby; and the relative adjustment of the contiguous ba perhaps not quite so good as at Whitby. In respect of adjustment each panel of bands or prisms, this part of the structure may be c sidered an exact counterpart of the north light-house at Whitby. T image of the horizon, as formed by the dioptric bands, is somew more than an inch above the lamp metal, and all parts of the lamp-fla above that height are effectual on the sea, by operation of the diopt band. But from the lower prisms scarcely a ray reaches the sea, a from the upper prisms the light of a very small part only reaches sea. They are practically useless.

In considering this instance, as also those of the two Foreland lig (both constructed by French artists employed by Messrs. Wilkins,) those of the Whitby lights, (constructed under the immediate direct of a French gentleman, Messrs. Chance's foreman,) I am inclined think that a faulty rule has been, at some time, given by some practi authority in France, and has been slavishly followed in France England.

Exterior to this fixed ring frame is a lightly-constructed revolv frame, carrying (at equal distances on its circumference) three verti panels, each composed of vertical bands, nearly similar (*mutatis* *tandis*) to the dioptric ring bands. The intersection of these vert bands with the horizontal bands or rings ought to produce exactly effect of a lenticular panel. I was taken by surprise by this const tion, and did not sufficiently examine the accuracy of the horizo convergence of the rays. But having heard subsequently from pilots at Dover that the light-house exhibits three flashes in the pe of 4*m*., (the time of revolution of the frame,) of which one is m brighter than the other, and having seen from Dover the extraordinary brilliancy of that flash, I am disposed to think that one of the flames is very well adjusted, and the other two very ill.

The central pillar bears the name "*Francois jeune.*"

In the practice of adjusting the lamp there is a very great difference from those of Whitby. The rule is, to burn the flame to the height 0.10 meter, or more than 3.9 inches, and it was fully at that height when I saw it. With the dioptric part, probably the most brilliant light of the flame reaches the horizon, and nearly the whole of the sea is illuminated. This effect is very good, but might be considerably improved by proper adjustment of the reflecting prisms.

The lamp is fed by a pump. (For lamp glass, see Grisnez, below. For remarks on the reflectors in the blank sides, see Grisnez, below.)

2. The Small Light at Cape de Walde, or Valde. This is a fourth-class light, and deserves no notice except as a specimen of a light-house with prisms, &c., made of cast unpolished glass. It is quite sufficient to condemn the system, even for such a little instrument as this. The quality of every surface is wretched; the form of every surface is faulty; the surfaces frequently have contrary or ogee curvatures. The proportion of light sent in any desired direction must be very small indeed.

3. The Light of Grisnez. This is similar to that of the Start, (lenticular arrangement for the dioptric part, looking-glass reflectors for the catoptric part.) There are the following differences of detail: Instead of eight divisions, as at the Start, there are sixteen at Grisnez, and the number of reflectors at Grisnez is smaller than that at the Start. In the truth of the workmanship of the lens rings there is a prodigious difference. The rings at Grisnez are so truly curved that the line of the sea horizon is seen to traverse all above or below the centre, without any clinging to the circumference, or any tooth-like interruption, as at the Start. Upon examining the adjustment of the dioptric panels, and of the looking-glass mirrors, it was evident that, supposing a good flame on the lamp, every one of these would send light to the horizon and upon the sea, losing very little in the sky. The adjustment of this, now an old fashioned apparatus, is far the best that I have seen.

The keeper appeared to have no fixed rule of 0.1*m.* for the height of the flame. The height which he exhibited with his fingers was less than 0.1*m.*, perhaps 3 inches.

I omitted to examine the lamp feeder.

In the lamp glass here, as well as at Calais, the form of the glass differs much from that in the English lamps. The contraction of the diameter, instead of being made by a square shoulder, as in the Whitby lamps, is made by a gradual slope of about 1¼ inch.

The diameter of the lamps is 3¼ inches, sensibly the same as that of the English lamps, The number of concentric wicks four.

In this light-house, and in the Calais light, there are large reflectors on the blank sides. I believe that they are better shaped than those in the English lights, but they are so wretchedly dull (scarcely brighter than a pewter plate) that I do not conceive them to have any sensible utility.

4. The South Foreland upper light. This is a fixed light, precisely similar to those of Whitby and Calais. The glass is French, (Lepaute,) furnished by Messrs. Wilkins. The dioptric part is fairly good, but

with more veins than in those of Whitby, Calais, or North Foreland, and the curvatures are not quite so well worked. In the catadioptric part some of the prisms are abominably veiny, never through their whole length, but through about half, indicating some peculiarity in the manufacture of the glass. One or two of the lower prisms are sensibly out of adjustment, as compared with the others.

As regards the action of the lamp through the central dioptric part, the flame to the height of 1⅛ inch throws its light to the sky. The lamp flame is maintained to the height of 2¼ or 2½ inches, and a great deal of its best part is effective on the sea.

As regards the catadioptric parts, the lower part is very nearly useless, and the upper part almost useless, as at Whitby and Calais.

There are reflectors for the blank sides, bright, but irregular in form, as at Whitby.

Lamp 3½ inches diameter, with three wicks.

The light keeper said that there was great trouble in maintaining, with the fountain apparatus, a uniform high light, because when the oil was cold scarcely enough was supplied, and as soon as the lamp heated it ran over too copiously.

The reduction of the lamp glass is not so square as at Whitby, and not so sloping as in the French lights.

This is an effective light, but admits of being much improved.

5. The North Foreland light. Exactly similar in form and arrangement to the Whitby, Calais, and South Foreland. The glass is beautiful, (none but the Whitby glass comparable to it,) the dioptric band well worked, (not quite so well as at Whitby,) the catadioptric prisms well adjusted together. The useless portion of flame for the dioptric part 0.9 or 1.0 inch high. Height of flame, as I understood, near three inches, (the oil is supplied mechanically.) The catadioptric parts are nearly useless, as in the Whitby lights. Bad reflectors on the blank sides, as at Whitby.

The lamp, as at Whitby and South Foreland, but there is a more careful apparatus for adjusting the height of the lamp glass, which is praiseworthy. Lamp glasses as at South Foreland.

An effective light, but admitting of improvement.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., June 29, 1860.

MY DEAR SIR: I enclose a letter which I have just received from Mr. Chance. It is clear, I think, that by judicious co-operation with him, we may do much to improve the light-houses.

The note from Cookson's workman on the Start lenses is, at first, a little obscure, but I understand it perfectly. The rings and the central lens were all ground at once by a bowl-shaped grinder, as I suspected, a very different process from the cross-stroke grinding at Chance's. This rude note ought to be preserved as a very interesting document for the history of the practical science.

My first recommendation to the powers would be, the Start light must be entirely remodelled. It is a light of great importance.

Now, what in your judgment would be the best way for bringing together the Trinity Board, and Mr. Chance, and ourselves, for the improvement of the Whitby lights? It may well be done before you make your report, and the amended state may make a good chapter at the close of the report.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., July 3, 1860.

MY DEAR SIR: I return the proof of Abstract of Evidence on Light-houses, &c., as I must be clearing in reference to my journey to Spain.

I have no doubt that the failure of the Whitby high lights, to which you have directed my attention, is *simply* in consequence of their optical badness.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., July 4, 1860.

MY DEAR SIR: I return the letters of Captain Ryder and Mr. Campbell.

I like Mr. Campbell's proposal of shifting the individual reflective prisms, *but for the lower prisms only.* The diverging form of the upper prisms (which are more important) will not permit the change.

In regard to Captain Ryder's proposed order of action, this is one of the matters of high *politique,* in which I am not competent materially to interfere, only I say—

1. The Whitby light is the most flagrant instance of mismanagement.
2. The constructor of every part of the Whitby apparatus is at hand.
3. The said constructor is willing to go heartily into the improvement of the Whitby light.

Therefore, leave all others and rest on it.

And I also say, as far as the Trinity Board is concerned, do everything openly and frankly towards them.

This in readiness for our possible meeting.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., August 1, 1860.

MY DEAR SIR: The point which I wished to have specially investigated in the High Calais light-house is this: The frame is fundamentally that of a fixed light, distributing its light equally all round to a certain angular extent, or, at least, throwing the same constant light to Dover, (for instance.) And this constant light is varied by the rotation of a moveable frame, which embraces the fixed light apparatus, and which carries three sets of vertical glass prisms, with surfaces so curved as to produce (generally) the same effect of refraction in a horizontal plane which the dioptric band produces in a vertical plane.

If these vertical glass prisms are properly adjusted, then, every time that any one of the three frames is turned towards Dover there will be a concentrated beam of light of great intensity thrown to Dover.

But it appears that, in point of fact, only one of the three beams thrown in the course of a complete rotation possesses any great intensity.

From this I infer that one of the three sets of prisms is well adjusted, and that the others are not.

The test would be this: Select an object at a considerable distance, *not* a horizontal line like the sea horizon, but a *vertical* line like a lighthouse, or a point or small object like a ship. And when the prism frame under trial is turned towards such object, remark where the image of such object is formed,* *not* in regard to up and down, (as we have done for the ordinary tests by sea horizon,) but in regard to *right and left*, and see whether its image, as viewed through the whole horizontal range of the prism frame, is in the same position (with regard to right and left) for every one of the prisms, and for the whole breadth of each; and whether the said image is well formed by each; and whether all the said images are formed very near to the vertical axis of the lamp.

All the images ought to be well formed and united at the vertical axis of the lamp, and any fault in these respects would injure the action of the apparatus.

The prism frames ought not to throw the image of the sea horizon up or down; this, also, should be examined.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., August 6, 1860.

MY DEAR SIR: The points which struck me most in our late visit to the North Foreland light, as additions to what I had previously recorded, are the following:

1. The performance of the lamp was very bad; the flame, when steady, was much lower than when I saw it before. This circumstance, however, assisted by the depression of the lamp flame, (made, as I understood, within a few days,) brought out far more clearly than could otherwise have been done, the imperfection of illumination on the horizon and on the sea. When I saw the light-house before, there was good light on both from the dioptric part, the flame being then respectably high.

2. I suspected, from recollection of my former observation, and I now fully confirmed it, that the curvature of the reflecting surfaces of the

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*See, however, the last paragraph.

upper and lower prisms, but especially of the latter, is much too sharp. In the instance which I measured best, (second lower prism,) the horizon image, instead of being formed on the lamp, was formed eleven inches before reaching the centre of the lamp. The effect of this was to disperse the light up and down. In the present generally erroneous adjustment of these prisms there may be advantage in this, because it throws some light on the sea; but if the prisms were generally well adjusted, much of the light which would fall with great force on the sea would be lost.

3. From a remark made by Mr. L. Sauter, it is plain that the peculiar effect of *reflection* is not fully understood by him. He said that the adjustment of the reflecting prisms was adapted to high flame but not to a low flame. But, in reality, an addition to the height of the flame (though very valuable for the dioptric part) adds nothing to the useful effect of the reflecting part, as I have repeatedly stated, and Mr. Sauter's remarks, therefore, must be without foundation, and expressed without clear understanding of the matter.

It occurs to me to suggest for Professor Faraday's consideration, whether, in a place so accessible, gas might not be used, either manufactured on the spot or led from Margate.

I intend to suggest to Mr. Chance some experiments for determining the special section of the lamp flame which will send to the horizon the most brilliant light through the reflecting prism.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., August 9, 1860.

MY DEAR SIR: I enclose a tracing of a sketch that I have made of the way in which I think the questions of adjustment of the reflecting prisms of light-houses must be treated. I do not mean it as perfectly correct for angles, &c., but rather as a specimen of method.

I send a copy of it to Mr. Chance.

I am, &c.,

G. B. AIRY.

You will remark that I still confine my practical ideas to oil lamps, or (which in form is the same thing) to gas lamps. I hope to see the galvanic light introduced, but it will require a very extensive change of lenses and reflecting prisms, and, therefore, will come very slowly. I am prepared with the principal considerations that will then have to be examined.

G. B. A.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., September 8, 1860.

MY DEAR SIR: I returned yesterday morning, but had no leisure to write to you yesterday or this morning. This letter will be posted on the 10th.

I enclose M. Reynaud's letter, which would have been of the utmost importance to me if I had gone alone, and was probably extremely useful in the actual case.

My course of journey was this: On Monday, the 3d, I went to Dover by 4.30 train, expecting Captain Ryder either by that train or by the next, and proposing to cross by the morning steamboat; but the night became very fine and calm, and I determined to cross by the night boat, established myself at Dessin's, and in the morning worked off the Calais light-house. Finding that there is a diligence to Boulogne at 12, by which time the morning steamer would be in, I took two places on the diligence, and waited at a corner of a street for the steamboat passengers, and there I picked up Captain Ryder. Then we went by the diligence (very slow) to Boulogne, and by railway to Abbeville, where we slept. On the morning of the 5th, at 10 o'clock, went by diligence to Dieppe, arriving at past 4. It was too late to do justice to Cap d'Ailly, so we arranged for starting at 6 o'clock the next morning, with the hope of quitting by the boat at 10.40 a. m. On the morning of the 6th started at 6 o'clock, reaching the light-house about 7.30, and proceeded to work, when a fog and shower came on which destroyed our horizon. We were compelled to wait so long that the steamer was effectually lost, so we transacted our business leisurely, repeating some of the examinations several times. Started by the steamer at 10.50 p. m.; was too ill to compare the Cap d'Ailly and Beachy Head lights. Reached Newhaven on the morning of the 7th, and came to London and Greenwich.

1. In walking backwards and forwards on the Dover pier, I remarked the way in which the South Foreland high light comes into sight over the shoulder of the Downs. It appears as a very dull spark, very slowly increasing, till at last it rises rather suddenly into considerable brilliancy. I interpret it thus: The first view is of the upper prisms, which are so imperfectly lighted that even when all are in view their light is small, and, therefore, as they come gradually into view, the volume of light, small at the utmost, has increased slowly; at length the central panels give their light, which (from the circumstances of adjustment) is much more effective.

2. Shortly after leaving Dover harbor, the South Foreland lower light comes into view. There was no mist whatever about the Downs, and both lights were seen perfectly well all the way to Calais. As the bearings of the lights slightly changed, their relative brilliancy slightly altered, (evidently from window bars, position of reflector edges, &c.) The result of very careful examination was that the lights are exactly equal, sometimes one and sometimes the other being the brighter. Now, the lower light is an old parabolic mirror light, and the upper is a new first-class dioptric and catadioptric glass light. I conceive that this comparison is discreditable to the upper light.

3. The great Calais light rose suddenly from the sea at about one-third passage over, with good light and great brilliancy at its brilliant phase. Of the apparently triple phase I will speak hereafter. On the voyage I timed the brilliant phase and found the intervals to be four minutes.

4. I saw the light on the sands, which we had visited, (the sailors call it Cape Walldam.) It really gives a more respectable light than I could have expected from such an unnatural contrivance.

5. In the Calais light-house I examined very carefully the three movable sets of vertical prisms, and found all to be in excellent adjustment; a single prism in a single set being so far out of adjustment as to throw the image of a ship about ¼ inch to one side, which is of no importance, and none of them disturbing the horizon. Their focus is nearly one inch in front of circumference of lamp, which does no hurt. (It would do hurt if the light were a galvanic spark.) I was a little puzzled about the apparent difference in the triple flash, till I had the clockwork attached, and the instrument moved "*au naturel*," as the man phrased it. I then tried the passages of the successive sets of prisms, and found the interval from set No. 1 to set No. 2 to be four minutes, and that from set No. 2 to set No. 3 to be four minutes, and the same No. 3 to No. 1; the whole time of revolution being twelve minutes. It was plain, therefore, that the apparent triplicity of phase, whose period is four minutes, does not belong to a difference of adjustment of the three sets of prisms, but is something peculiar to such prisms, and is the same for the three sets. And now I found the explanation. The vertical prisms absorb all the light of the central panels a little before and a little after the brilliant flash, (leaving only the light of the reflecting prisms,) and collect that light for the flash.

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The pilot, who remarks that after *a* the light suddenly declines, sets down *a* as a flash: then comes the great flash, *b*, about which there can be no mistake: then the light suddenly rises to *c*, and the pilot considers this to be a flash. My first interpretation of all this was erroneous; and I am glad to have had the opportunity of correcting it. The correction is worth the journey.

6. I looked, but in a mere cursory way, at the general optical arrangements of the glass rings. I found those of the dioptric part very good (as before) for a large flame, the image of horizon being about 1.5 inch above the lamp-metals; and those of the reflectors, as before, to be defective, but not so defective as in the English lights.

7. In glancing at the machinery of rotation, in an engineering point of view, I found a fault which I could not have anticipated. Between the fixed plate and the revolving plate there is a chain of live rollers; and the diameter of each roller bears a large proportion to the diameter of the ring on which it runs. The slightest consideration would show that the fixed surface and the movable surface one or both ought to be conical, their vertices meeting at a point, and the rollers ought to be conical, their vertices being at the same point. To my great astonishment, I found that the plates are both flat: the rollers consequently are always scraping upon the plates, either with the inner edge of bearing, or with the outer edge. The keeper told me that the rollers at first were of iron, and so much of scales was torn up every night that it was necessary to sweep the plates every morning. Rollers of gun-metal are now substituted, and the metal does not tear them up as before: but there must be very great and unnecessary friction and very unnecessary labor is thrown on the clock.

8. In descending from the light-room I found the chief [illegible] (whose name I forget.) He had been greatly disturbed [illegible] of the visit which he had expected in July. I explained the delay [illegible] He spoke with contempt of the [illegible] light [illegible] regarded as

remarkable only for something picturesque in its position. All his admiration is fixed on the light of Belle Isle, which he describes as having this peculiarity, that the coupole or external window frame revolves with the revolving-light frame. It is evident that there may be advantage in this. I conceive that this light might be well worthy of a visit, or at least of a special inquiry, principally for the engineering arrangements.

9. My examination on all these points of the Calais light-house was so complete, or at least so satisfactory to me, that I had no scruple in arranging for Captain Ryder's proceeding at once, as I have said.

10. The Cap d'Ailly light contains eight lenticular dioptric panels, (revolving.) The upper catadioptric prisms are connected with and revolve with the dioptric panels, and are, in fact, a continuation of the same system, the prisms being rings referred to *nearly* the same horizontal axis as that of the dioptric panel. But the axis is not *exactly* the same, because the panel of upper catadioptric prisms is hitched about two inches on the panel of lenses. The lower catadioptric prisms are fixed horizontal rings.

11. The lamp is fed by pumps. Its height is adjusted every three weeks, (this cannot be done with a fountain lamp, on account of the pipe communication.) The oil is filtered through two inches of sand, in the lower store rooms, before first use and after each passage through the wicks. There are holes in the upper metal chimney into which there is a strong suction draft. The wicks were not cleaned from the night's work, and there was more than ¼ inch of char. On lighting the lamp the men could not get a 4-inch solid flame, but the average height was about three inches above the metals. The man played a good deal in adjusting the glass, (a glass with a very gently-sloping shoulder.) I inquired whether he would like a rack-and-pinion movement, but he rather objected to it, for the following reason: Sometimes the top of the glass melts, (from the heat,) and becomes engaged with the iron chimney in such a manner that there would be difficulty in extricating it by a mere raising and falling motion without a rotary motion, which the rack-and-pinion cannot give, but which the fingers can give.

12. The name is Lepaute, the date, I think, 1820.* The mechanism of rotation has the same fault as that in the Calais light-house, (see paragraph 7, above.)

13. I commenced the optical examination on the sea horizon, but after the loss of it I used a well-defined point of cliff, two or three miles southwest, on which the line of horizon was well known; and this was found to be an excellent mark, because there was no uncertainty about its identification, (which, with several parallel streaks on the sea and sky, is sometimes very difficult in the narrow prisms,) and because I could instantly see whether the divergence forming the image was too near or too distant. When the horizon cleared again I examined it as a sort of verification, but found nothing wrong in my conclusions.

14. The image of the sea horizon formed by the dioptric lenses is 1.5 inch above the lamp metals, and very near the centre. The lens rings are very well worked, so that in viewing the horizon image over the lamp across the upper or lower parts of the lens, there is no sensible hitch or tooth from ring to ring, or from panel to panel; very different

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*Perhaps a mistake.

rom the Start, but similar to Grisnez; at the same time showing greater kill than is necessarily shown at Grisnez, because the Cap d'Ailly panels include each one-eighth of the circumference, while the Grisnez panels have only one-sixteenth of the circumference. These Cap d'Ailly panels must (with a lamp flame exceeding three inches in height) be very effective, and must give a great blaze of light to the horizon and on the sea.

15. On trying the lower catadioptric prisms, I found that the image of the sea horizon was, I think, in every instance, (Captain Ryder has taken accurate notes,) thrown above the front edge of the lamp metals, not quite so high as I could wish, but respectably high, and these prisms really are efficient. They are the first that I have seen which deserve that epithet. I did not very specially remark the distance of convergence forming the image, but I am sure, from my general remarks, that it must have been very near the centre of the lamp. Every effective prism was examined.

16. On trying the upper catadioptric prisms I found that, with insignificant exceptions, (for which I refer to Captain Ryder's notes,) the position of the image of sea horizon may be thus stated: For the lowest prisms it is formed by rays whose directions fall on or a little above the rear edge of the lamp metals; for the highest prisms, it is formed by rays whose directions fall nearly on the centre of the lamp metal rings; for intermediate prisms, in intermediate directions. * * *

In every prism a brilliant light is sent to the horizon and a large body of light on the sea, I should say four times as much as at Calais and six times as much as in any other light that I have seen. I think that, for my own entire satisfaction, I should have raised the path of rays even a little more; but the general course here is so good that I would not on any account touch these adjustments. I ought to mention that we examined every one of the upper 88 prisms.

17. The accurate optical image of the cliff point was in all instances formed sufficiently near to the centre of the lamp. In some instances it was a little (perhaps two inches) in front of the centre; in others it was as much in rear. The latter are usually those which in Captain Ryder's notes are marked as "confused." There is no ground of complaint on that account.

18. On the whole, I pronounce this light-house to be in excellent adjustment, and far the most efficient that I have seen. M. Reynaud has reason to be proud of it.

19. The concave reflectors, which occupy the three land-side spaces, are as dull as those in other French light-houses; by no means so brilliant as an ordinary pewter pot.

20. On viewing the light in the evening from Dieppe, (where it produces a very splendid effect,) I remarked that between two bright flashes there are two intermediate little flashes, so faint that they would escape ordinary observation. Captain Ryder, in verifying this, was rather inclined to consider them as successive sudden degrees of elevation of light. I am not able to explain their origin.

I suppose that it will not be necessary for me to visit any more light-houses.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c

ABERDEEN, *October* 10, 1860.

MY DEAR SIR: I have to make the following report on my examination of the Girdleness light-house.

I arrived, with my son Hubert, at Aberdeen, on the evening of Monday, October 8. On Tuesday morning I was visited at the house of John Webster, Esq., by Mr. Alexander Cunningham and Mr. Thomas Stevenson, Secretary and Engineer of the Commissioners of Northern Lights. With these three gentlemen and my son I proceeded to the Girdleness light-house.

This light-house contains two systems of lights. The lower, at about two fifths of the height of the building, consists of thirteen parabolic reflectors, of the usual form, occupying with their light something more than the semi-circumference. I remarked in these that by a simple construction, which I have not seen elsewhere, great facility is given for the withdrawal and safe return of the lamps, for adjusting the lamps, and for cleaning the mirrors. I made no further remark on these, but proceeded to the upper lantern.

The light-house here is that of a fixed dioptric and catadioptric light of the first order. It was erected by Mr. Alan Stevenson, thirteen years ago, (as I understood.) The light-panels bear the name of Francois. The support of the light-frame is not a central pillar, (as in most modern light-houses,) but a diagonal-braced frame supporting the circumference, which I greatly prefer. The lamp is 4-wick, of the usual size, fed by pumps. The arrangement of the glasses is as at the Whitby and Foreland lights, &c., with six rings of prisms below, and thirteen above. The rings, both the dioptric and (as I believe) the lower catadioptric, are bounded, not by vertical bars, but by inclined bars, all sloping one way; the oppositely inclined bars, necessary for firmness of mechanical support, being within the glasses. This appears to me to be a good plan, preferable to that of rectangular bars, both optically and mechanically. The quality of the glass is excellent, quite equal to that of any other which I have seen.

On examining the image of the sea horizon, which was remarkably clear, as formed by the dioptric band, it was at once evident that it (the image) was a little too high. With some sections of the band, it was about 1¼ inch (I believe, but I had lost my means of measuring) above the metal; with others about 1⅜. Mr. Stevenson produced a drawing of the lamp, on which the due position of the focal line was marked; and I showed him, and he at once assented, that the lamp was too low by about ⅜ inch. The relative adjustment of different rings of the dioptric band, &c., was good. I then examined the lower reflectors, and at once saw what I had never seen before. The principles which I had been anxious to carry out regarding the due flood of light upon the sea are *fully* carried out. In every instance the rays coming from the sea horizon pass above the front edge of the lamp metal by about or near half an inch, measured perpendicularly to the rays, and and in the third reflecting ring from the bottom by a full inch. In fact, my principle here is rather overdone, but this will be corrected by the same elevation of the lamp which corrects the action of the central dioptric band. Then I examined the upper reflectors, and here I found things very perfectly to my satisfaction. The rays coming from the sea horizon through the few lower prisms of the set pass well above the rear of the metals, those which come from the highest fall nearly on the centre.

Remarking how well the important upper set of prisms are adjusted, and that the adjustment which the central band and lower prisms seem to require would slightly injure the action of the upper prisms, I suggested to Mr. Stevenson that he should not raise the lamp by the full $\frac{3}{8}$ inch of which I have spoken, but perhaps by $\frac{3}{16}$ inch.

The lamp was lighted for my inspection, and I was able to point out more distinctly to Mr. Stevenson that elevation is required, and that the quantity required is small. The lamp flame had scarcely acquired its full height while I remained at the light-house, but it appeared to be approaching the French height. The lamp glass has the gently inclined contraction. I could almost imagine that the draft is too sharp, and that the lamp would burn better with holes in the chimney above the damper, so that the damper aperture would by wider.

This light-house has evidently been most carefully planned for the actual depression of the horizon, and has been maintained in good, though not quite perfect, daily adjustment; but the correction required, even now, is extremely small.

It is the best light-house that I have seen.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH,
October 20, 1860.

MY DEAR SIR. On returning hither I find a letter from Mr. Thomas Stevenson, which is interesting as regards the history of the manufacture of light-house optical frames, and which I therefore transcribe at length:

"*October* 10, 1860.

"I find, on looking up our old books, that the upper Girdleness light was changed from the catoptric to the dioptric system in 1847.

"I forgot to mention, when speaking of Francois as the manufacturer, that in this, as in the other dioptric lights, all that was furnished in France was the glass prisms, and that these were afterwards all fitted together in brass frames made at Edinburgh under Mr. Alan Stevenson's immediate inspection. The only exception to this was the lens in revolving and the cylindric refracting belt in fixed lights, which were always sent in their brass frames by the French manufacturer."

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH, S. E.
October 27, 1860.

MY DEAR SIR. The enclosed letter from Mr. Chance, of October 26, will, I think, interest you. You will see how heartily and frankly he enters into our views.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

"HAMSTEAD, BIRMINGHAM,
"*October* 26, 1860.

"MY DEAR SIR: When I wrote to you from Whitby I expressed m self as doubtful concerning the advantages of adjusting dioptric app ratus by the image of an external object.

"I am now quite delighted with this mode. Not only does it secu greater accuracy of adjustment of the glass itself, but, what is ve important, it affords greater facilities for adjusting the glass while t metallic frame is in its actual ultimate position in the apparatus.

"This is a great point to be accomplished, and whatever method t manufacturer may see fit to employ, he ought to be required, I thin to adjust the glass in the frames *after* those frames are fixed in the respective positions in the general apparatus.

"The system adopted, until quite recently, quite precluded the p sibility of any such method, for the manufacturer was asked to supp generally only a number of *isolated* panels. For instance, one firm has present an order for portions of an apparatus to be put together th in detail, the framework being made elsewhere.

"Most truly yours,

"J. T. CHANCE."

ROYAL OBSERVATORY, GREENWICH, S. E.
November 10, 1860.

MY DEAR SIR: I may perhaps consider that a proper time has arriv for the expression of my general opinions regarding the conduct of t English light-houses. It was my first intention to submit to you a swers to the specific questions contained in the printed letters of t Commission; but the examination of several light-houses, of whi examinations the details have been placed before you, has in some m sure changed my views. and I think that I may do more complete just to the subject by presenting my ideas without reference to those qu tions.

The inspection of the light-houses to which I allude has reveal some faults which deserve notice, partly from their own specific c racter, but more particularly because they seem to indicate an ante dent fault in the system of organization under which they have be produced. Referring generally to my former letters for these, I will p ceed to state the course which I recommend, commencing with the p sonal organization.

1. It appears to me that there is no person officially connected w the Board of the Trinity House, who is distinctly responsible, eit for the correct construction and erection of the illuminating parts light-houses with reference to their optical effect, or for the contin maintenance of those parts in proper adjustment. I think it ab lutely necessary that an officer should be appointed, whom, for the sa of clearness, I will call "Optical Engineer," whose special duties sho be, not to construct or maintain the architectural fabric, which m be intrusted to the "Architectural Engineer," except in indicating requirements for elevation and other dimensions, and for store spa &c., but to construct and maintain in order the lantern-frame and la tern, the reflectors and refractors, and the machinery connected w

them, the lamps and their mechanism, and the oil or other combustible.

2. The education of the "Optical Engineer" ought to be somewhat peculiar. First, he ought to be a trained mechanical engineer, competent to manage all the requisite combinations of cast and forged metals, and the frames and the mechanism constructed of them. Secondly, he ought to understand the science of optics, in a form which is rather unusual, and which none but a trained mathematician can master. The knowledge of optics which is possessed, for instance, by an optical-instrument maker, is quite useless for the construction of light-houses. In no other working of glasses, except those for light-houses, is the understanding of the effect of "different curvatures of a surface in different planes normal to the surface, receiving rays of light incident at high angles of incidence" absolutely necessary. Thirdly, he ought to know something of the glass making; and ought to be perfectly familiar with the action of the large lamps under different modifications, as well as with lime light, galvanic spark, &c., which it may be proposed to substitute. But this knowledge requires less of preliminary training, and will come with experience.

3. Supposing such an officer appointed, the questions of the printed letters may be considered as in proper train for solution. There will be a person who can lay down rules for construction of light-house apparatus, or who can, if necessary, receive their suggestions, which sometimes may be guided by strict theory, and sometimes by practical convenience, and negotiate upon them; or who can arrange the special constructions required for difficult sea channels, unusual elevations, &c. It is unnecessary to say that it would be his duty to see the arrangements properly carried out, (a duty for which there appears to be at present no provision whatever.) I do, not, therefore, think it necessary, at this time, to enter into the details of those questions.

4. The principal part of the optical engineer's duty, for, perhaps, the first two years, would be the examination of existing light-houses, with a view of ascertaining whether they are, in respect of permanent fittings, independent of daily adjustments by the light-house keepers, in an efficient state. Where change is required, it will often be a question whether the change should be complete or partial. Thus, suppose it is decided that the Start light-house should be remodelled, it may be a fair question whether, in discarding its lenticular rings, its lenticular centres might not be retained. This review of light-houses will be a troublesome business, but is, in my opinion, absolutely necessary. It is only thus that we can arrive at the elimination of such faulty curvatures as those in the North Foreland lower reflectors; of such veiny glass as that in the South Foreland lower reflectors; of such imperfect lamps as those which I saw in the Whitby light-houses: and of such light-wasting adjustment as I have reason to think not uncommon.

5. Passing now to the material construction of light-houses, I think that, upon the whole, the construction now adopted, with some parts purely dioptric, acting by refraction only, and other parts reflecting light by internal total reflection in glass, with scarcely any refraction, is a good one. I prefer the internal glass reflection, to reflection from any known metallic surface which has been actually tried in practice a sufficiently long time. First, because I believe the quantity of reflected light to be greater; secondly, because I think that by the subdivision of

the whole reflecting surface into a moderate number of parts, greater accuracy can be given to the adjustments; thirdly, because if metallic reflectors were divided in the same way, they would bend and would be otherwise unmanageable. The curvatures, when the reflection is very oblique, require to be worked with exceeding care, which has not been given in every instance; but the excellent cross-stroke machinery now introduced in the best factories, with the modes of testing practised in them, are competent to give the required accuracy.

6. There is a fault connected with the dioptric part, which may hereafter prove a serious one, namely, the chromatic dispersion. Its effects are sufficiently conspicuous to the eye; for, even where the quality of glass is very good, it is impossible to see the horizon distinctly through the extreme edges. It would seem that the only way of diminishing it is to effect that direction of the rays of light by reflection; but the difficulty of ensuring accuracy of reflection at very oblique incidence is great; and on the whole I do not doubt that the angle at which refraction shall end and reflection shall begin has been fixed with good practical wisdom.

7. I can scarcely imagine that anything like achromatized prisms can be adopted with advantage. At the same time, I throw out this whole subject of accuracy of refraction as one which deserves careful consideration.

8. In the treatment of the whole of this subject I insist upon accuracy of reflection or refraction of the beams of light as a principle which ought never to be relaxed. It is true, that a large dispersion o the beam, perhaps five degrees, is produced by the size of the large o lamps; but if the faults of the reflector or refractor produce some dis persion, that dispersion is entirely added to the dispersion dependin on the size of the lamp flame, so that a dispersion which needs not t exceed five degrees may be amplified into nine or ten.degrees, and th brilliancy of light thrown in a given direction will be diminished in th same proportion.

9. I think that the experimental use of the lime light in the street and that of the galvanic spark at the South Foreland light-house, hav so far succeeded as to make the employment of these sources of ligh plausible. The question then arises, can they be employed with adva tage in existing light-houses? Here the first consideration will be, a the reflection and refraction in the existing light-houses sufficientl accurate? In the case supposed above (Article 8) of a lamp dispersio of five degrees, increased by an inaccuracy of dispersion of five degree the intensity of the beam of light was diminished to one-half of wha it ought to have been. But with lime-light, and *a fortiori* with ga vanic light, a lamp dispersion of less than half a degree would be i creased by the same inaccuracy dispersion of five degrees, and th intensity of the beam of light in a given direction would be diminishe to $\frac{1}{11}$th part of what it ought to be. Without saying that there is th amount of inaccuracy of dispersion in any of our light-houses, I do, a present, think it doubtful whether their workmanship and adjustmen are sufficiently exact to give the increase of optical effect which migh fairly be expected from those intense lights. When the change of ligh shall be seriously suggested, a special examination of the light-hous must be made.

10. Supposing such lights introduced with good effect, as regards the horizon and the very distant sea, it would be necessary to provide distinctly for the illumination of the nearer sea. For it must always be borne in mind, that the only way of giving intensity to a beam in one direction is to allow no light to pass in any other direction; and thus, to make the principal part of the reflectors and refractors available near the horizon, they must not throw any light on the near sea. This provision may be made, perhaps, in part, by throwing a portion of the chromatic dispersion on the near sea, or in part, by giving peculiar curvatures to one or two of the less important (the lower) reflectors, adapted to that purpose. For arrangements of that kind the talents of the optical engineer will specially be required.

11. If these brilliant and minute sources of light should be successfully introduced, it would be possible, theoretically, to reduce the dimensions of the lantern to a very small size. Whether this could be done practically is not quite so certain. Possibly the dimensions might, with due attention to the magnitude of lamp dispersion, be so far reduced that an error in position of $\frac{1}{8}$ inch, would be nearly ruinous to the effect of the light. Could we depend on the adjustments being maintained so exact? If we could, there would be some advantage in these small light cases. The glass might be selected of perfect quality; the loss of light from passing through a great thickness of glass would be diminished; possibly the grinding of the curves might be more manageable, and therefore more accurate; certainly the expense would be diminished. On many accounts, it is highly desirable to prosecute experiments on the easy and certain use of these sources of light.

These are the principal matters bearing on the practical administration of the light-houses which occur to me at the present time. Should any other ideas occur to me, I will have the pleasure of submitting them to you.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

ROYAL OBSERVATORY, GREENWICH, S. E.,
December 8, 1860.

MY DEAR SIR: I returned from Birmingham on Tuesday evening, December 4.

The business at Birmingham consisted chiefly in ascertaining the point of the lamp flame which might be considered as brightest, the trial being what part of the flame sent the most brilliant light to the screen at the end of the long gallery in Messrs. Chance's light-house factory. The optical apparatus used consisted of the bands forming one section of the dioptric part of a fixed light, every one of which was tried separately. The reflecting prisms were not mounted.

The first operation in the logical order (though not in the actual order of proceedings) was the verification of the zero of the scale by which the depression of the entire lamp frame was registered. For this purpose a small graduated standard was placed upon the lamp metals, and a gas burner was lighted at the bar near the distant screen, (which bar was always adjusted to the height of the band under trial,) and its image was *observed upon the* small standard as formed by different bands of the dioptric ring. In this manner it was found that, for th broad central band, and for each of the upper bands, when the depressio scale indicated 20 millimeters, the image fell upon 20 millimeters of tl standard in the axis of the lamp, and thus in subsequent experimen the depression of the entire lamp to any particular reading indicat that the optical image of the distant screen zero was elevated by th reading above the lamp metals. For the lower bands the adjustment ha been made to a constant reading, I think, 18 millimeters above the fro edge of the lamp metals, and this adjustment seemed to be fairly pr served, in correspondence with a depression of the lamp frame to millimeters.

On the evening of Monday, 3d December, the lamp being pump-fe the lamp glass, with gradually inclined shoulder, (like the French lan glasses,) and the flame very fully high for an English lamp, but not high as in the French light-houses, but forming a very good solid bo of brilliant flame, the experiments were tried upon one band at a tim simply by uncovering one band, covering all the others, and observi how the shadow of a horizontal bar near the screen, adjusted to t height of the band, fell with reference to the place of brightest illum nation. And I was struck with the general delicacy of this apparent rough method of trial. A change of one millimeter ($\frac{1}{25}$-inch) in t height of the lamp flame was in every instance detected by the chan in the appearance, as to whether the brightest part of the light fell fell not upon the horizontal bar, and in many instances a change of ½ millimeter ($\frac{1}{50}$-inch) was clearly discoverable.

The result of this evening's work was that the height of the brighte point of flame above the metals was from 21 to 22 millimeters, certain not more than 22.

The various bands agreed in this. The upper bands (adjusted for i tersection of axes of pencils to the same point as the special focus the central band) and the lower bands (which, though adjusted on different principle, as I have said) agreed in giving strongest light wh the depression of lamp or elevation of focus of central band above t lamp metals was 21 or 22 millimeters. The chromatic aberration i troduced some uncertainty, but the judgment of the eye became at la pretty decisive.

On the morning of Tuesday, December 4, the experiments we repeated essentially in the same way, but the lamp was in a better sta Its flame was, perhaps, ¾ inch higher than on December 3. It was at good French height, though not the highest. (I believe that a camer obscura trace made by Mr. Campbell will give accurate information the state of the flame.) The result now was that the point to be us for the brightest in the flame was 23 to 24 millimeters above the lan metals, and I believe that, on the whole, we were all inclined to pref 23 to 24. When we tried 28 millimeters the light on the zero of t screen was very much diminished. I felt very great surprise, and so believe did all who were present, that Fresnel could have fixed up such an element of adjustment. When the evil from thus throwi the light too high is aggravated by the dip of the sea horizon, (Fresne 28*mm.* adjustment being intended for geometrically horizontal ray which, for 20′ dip, corresponds to about 5 millimeters, in height *focus in* lamp, so that really 33 millimeters is the height to be tried, comparison with 23 or 24, which we found best, the loss of light is absurd.

A polyzonal lens was then mounted, and, generally speaking, it seemed to lead to the same conclusions. But the light upon the screen could not be observed with so much accuracy, because the lens produced a rude image of the lamp flame, and the eye was distracted by the images of the bright edges of the various cylinders of flame produced by the separate wicks, and by the colors which accompanied them.

It appears to me that two results of considerable importance have been attained in these experiments. (1.) We have ascertained with much accuracy the height to which the sea horizon focus ought to be adjusted. (2.) We have acquired a very good idea of the degree of accuracy at which the adjustments ought to aim.

After finishing our proper experiments, we saw Mr. Stevenson's light lantern for MacArthur's Head, which is a remarkable instance of the arrangements which an optical engineer of light-houses ought to be prepared to make when need requires. We also saw the frame of the Smalls fixed light, which an agent of Messrs. James Walker and Burgess came to examine. It is framed, for optical convenience, with inclined uprights, but I was not satisfied with their bracing.

We also saw the plans (apparently yet imperfect) for the galvanic spark light, to be mounted on the Dungeness light-house.

I had nearly omitted to mention one circumstance regarding the lamp. After two or three hours burning of the lamp, on the evening of December 3, it was found that the innermost wick was charred black two inches down. The outermost wick was very litle chared. It would be desirable, if possible, to prevent this.

I am, &c.,

G. B. AIRY.

Admiral W. A. B. HAMILTON, &c.

REPORTS, &c., BY PROFESSOR FARADAY.

REPORT, &C., TO THE DEPUTY MASTER AND BRETHREN OF THE TRINITY HOUSE.

ROYAL INSTITUTE, *August* 16, 1860.

The Royal Commission on Lights, &c., having desired to meet the brethren of the Trinity House at the North Foreland and Whitby light-houses, with certain other persons, such as the manufacturers of the apparatus, the representatives of the Irish and Scotch light-houses, the Astronomer Royal, &c., for the purpose of making certain practical communications to them, which could not be so well done by writing or elsewhere, such meetings have taken place. The one at the North Foreland occurred on the 2d of August, when there were present Admiral Hamilton, Captain Ryder, Dr. Gladstone, the Astronomer Royal, and Mr. Campbell, of the Royal Commission; Admiral Gordon, Captain Close, Captain Bayly, Captain Weller, of the Trinity House; Sir James Dumbrain, of the Irish Board; and Mr. Halpin and Captain Roberts; Mr. Stevenson, of the Scotch Board; Mr. Souter, of Paris, the maker of the apparatus, with Mr. Wilkins and myself. The other, at Whitby, occurred on the 9th of the same month, when the same persons were present, with the exception of the Astronomer Royal, Captain Weller, Sir James Dunbrain, and Captain Roberts, and the addition of Captain Nisbet, E. B. Trinity House, and Mr J. Chance, the manufacturer of the apparatus, with M. Masselin. I was there, on the part of the Trinity House, as their scientific adviser in experimental lights, and although I do not wish to assume the character or responsibility of optical or civil engineer, I feel it my duty at the call of the deputy master to give my impressions and conclusions. Having received no descriptive written document from the Royal Commission, I may, perhaps, pass by some points requiring attention unawares.

The object of the Royal Commission was, I believe, to point out the necessity of a final examination of the optic apparatus in the light-house itself after its erection, and the demonstration of a mode of making that examination in a practical manner, which I may call the method of the Commission. The object of the optic apparatus in a light-house is to convey the rays from the source of light to the sea horizon, or to the parts of the sea between that horizon and the shore, in the most abundant degree possible, and in the most favorable manner. This effect is obtained by a certain position and adjustment of the parts of the refracting and reflecting apparatus, and whether these are right in this respect may be ascertained by a process in some degree the reverse of the illuminating method. Thus, suppose the lamp is lighted, a given bright spot in its flame selected, and a given piece of the glass apparatus adjusted so as to transmit the light passing through it from the chosen spot to the sea horizon; then, if the adjustment be right, an observer placed on the other side of the flame, and looking through the spot and the glass, will see the horizon. And this is an observation easily made in the daytime, either with the flame actually existing, or with indicating gauges at the burner (as the edge of a card for instance) representing given or selected parts of the flame. If the horizon does not appear in the right place the adjustment is wrong. The same kind of test may be applied to every part of the apparatus, in turn, whether refractive or reflective; in respect of any part of the horizon, or the sea, or the sky; and in respect of any part of the flame or luminous object. A luminous point being selected, that place which the eye sees through it will be the place to which the rays issuing from it in that direction will proceed.

This appears to me to be an excellent practical application. In principle it is perfect. The application, however, cannot be equally perfect, because of the inevitable imperfections of construction. Still, the quality of the glass and its workmanship have arrived at such a degree of excellence as to justify the application of this refined kind of inspection, which may be anticipated and worked up to by processes applicable in the manufactory.

Assuming that the apparatus is as perfect in its execution as can be expected, then the causes that may interfere with the due effect (and chiefly by mal-adjustment) are several. First, those connected with the *lamp and flame*. The Fresnel lamp has a burner and cottons having a horizontal width of 3¾ inches in diameter. The flame, as it rises from this base, is obscure above and near to the cotton, then becomes luminous and powerful, and contracting as it rises, usually ends in a series of forky tongues. When supplied by an overflowing lamp, urged by the draught of a good chimney, the bright part of the flame may be from $2\frac{1}{4}$ to 4 inches from the bottom to the top of the chief tongues of flame. These latter have no smoke at their tops, and the horizontal section passing through the widest and brightest part of the flame will be from $\frac{6}{8}$ to $\frac{9}{8}$ of an inch above the burner. It is assumed that this section should coincide with the focal plane of the lenticular bands, or merely refracting part of the apparatus, for then the most powerful rays proceed in a horizontal direction, and will fall on the sea horizon when the light has little or no elevation above the sea. All the light which emanates below that plain, and passes through the lenticular bands, will be thrown up into the sky above the horizon; but all that emanating from the great body of the flame above that plane will be cast over the sea, between the horizon and the shore, doing good service to the mariner.

The selection of this plane, or of the point in the centre of the flame coinciding with it, which is called the focal point in respect of the refractors, is of great importance. By numerous experiments and trials in France, it is considered as 28*mm.*, or 1.05 of an inch above the burner. Now, the brightest horizontal section of the flame may be 1.12 inch above the burner with a well arranged overflowing lamp, or only 0.75 of an inch above it, with a low flame and non-overflowing lamp; and the adjustment in height of the lamp which would suit the first and send a fine body of light from the upper part of the flame over the sea, would, with the latter, send little to the sea, and the greater part of the light to the sky; so that not merely has the adjustment to be attended to, but also the lamp suited to the adjustment.

As far as my observation goes, the lamp should overflow freely, so that only one-fourth of the oil that passes over and through the wicks should be burnt. It should, in the case of a first-order lamp, have four wicks, and a chimney of glass and iron 6 feet high. As much oil as possible should be burnt without smoking, for when in a good state the light is as the oil burnt. The lights at Whitby had not overflow lamps, and only a certain amount of oil could be burnt, and a certain height of flame (lower at the south than at the north light-house) be obtained. By making the oil overflow and raising the wick, the flame was raised at the base, but began to smoke. By virtually lengthening the chimney, through the application of paper valves, the whole flame was raised both at the base and at the summit, and the combustion very greatly improved, and that continuously. But the adjustment of the optical part of the apparatus fit for the one state of flame would not be fit for the other. Being examined in the manner proposed by the Commission, if the combustion were low, the ray proceeding from the eye to the horizon would be much too high in the flame, whereas, with a full and proper flame, it might pass in the best direction, for the difference in level of the brightest sections of two such flames may be as much as $\frac{3}{8}$ of an inch, and every diminution in the good condition of the flame, whether from the construction of the lamp or inattention, tends to rob the flame at the upper or sea-supplying part.

In respect of the reflectors, circumstances are different. The whole of the flame radiates light towards each of the *upper reflectors*. If the eye be so placed (as in the Royal Commission process) as to see the horizon through the flame, in the middle of one of the reflecting prisms, then all the flame above that line will throw its light into the sky, and only that part below the line will throw its light on to the waters. Hence, the line through the flame, or rather through its projection at the reflector, should go through a bright and abundant part of it, and should also leave as much as possible of the flame below that line, since that is the part which radiates light to the sea; *i.e.*, the observer's ray should be taken as far back towards him, and as far up, as is consistent with a good line of flame for the horizon, and then the reflector ought to be adjusted so as to throw this light which has reached it onward in the right direction. As regards the upper reflectors, generally a point in the centre of the flame, 1.55 inch above the burner, is from careful experiment considered as that which gives the best result, and is called the focal point for the upper reflectors, being common to all.

In respect of the lower reflectors, matters are very different. The burner and cottons cut off much of the light of the flame from them. With the best flame one-half of the light is thus lost, and with a low flame only a fourth or a fifth may pass to them to be utilized. The line of sight should, as regards the observer, be taken as far forward and up as is consistent with its passing through a bright part of the flame; for here again it is the part of the flame below this which sends light to the sea, whilst the part above casts its rays into the sky. In the French experience and practice, not one focal point but several foci are taken for the different reflecting prisms. These are points in a vertical line in the centre of the flame, (the lowest focus is for the upper reflector, and the highest for the lower reflector,) and they are, respectively, at the following heights above the burner, 38, 42, 47, 53, 60, and 68 millimeters.

The lamp, optical apparatus, and adjustments which I have referred to, have had reference to a horizontal line; and it is so, that nearly all the apparatus made in or for England have as yet been so constructed; but the *sea horizon* does not correspond with a line horizontal at the light-house. It forms an angle with it, and that so much the greater as the light is higher above the level of the sea. At the North Foreland the two make an angle of about 14′.2, and at Whitby of about 16′.5. Hence, if the chief ray of light be sent horizontally, it will pass over the sea and be wasted; and, indeed, more light with it, even the 16′.5 seconds, which ought to fall on the sea. This condition is seen at the Whitby light-houses, by the Commissioners' mode of examination, a little modified. To correct this error for the lenticular bands, it would be sufficient to raise the lamp an equal number of minutes, (about $\frac{1}{6}$ of an inch for Whitby,) but such a proceeding would increase the error for the reflectors, both above and below, and can only properly be met by instructions to the maker of the apparatus at first.

The French authorities only take account of this difference between the sea and true horizon when the height of the light is 60 meters (about 200 feet) and upwards above the sea. For my own part, I do not see why it should not be taken into account for a height of 50 feet and upwards. Twelve or thirteen years ago, the Lundy light had its chief rays sent to the sea horizon, and I made an instrument which was used by Mr. Wilkins for the proper adjustment of the reflectors. Since then the reflectors have been changed for others on the catadioptric principle, and these have their rays directed horizontally as at first, and the same rule has held ever since. Mr. Chance tells me he is *now* constructing apparatus with the rays directed to the sea horizon.

Cases may arise where a high light, not being a leading light, might
etter have its chief ray sent, not to the extreme sea horizon, but some
ntermediate distance, where in hazy weather the light might require
o be in some degree concentrated. Such cases are nautical in their
ature, but if they occur, instructions should be given to the maker
eforehand, since the correction or adjustment cannot properly be made
fterwards.

The first application of a new and searching method of examination,
ot applied until after the workmen have been fitting and handling the
eavy parts of the apparatus in the lantern of the light-house, may
iscover either derangements of the whole or of parts. From the ex-
ressions of the makers, M. Sauter and Mr. Chance, I understand that
hese can be rectified in apparatus already erected, and can be pre-
ented in apparatus to be made hereafter, so that the test proposed
akes no undue claim on the manufacturer.

The Royal Commission, when at Whitby, pointed out certain deficien-
es in the illumination of the sea, and the waste upon the sky of a
ortion of the light which the lamps sent to the glass apparatus, both
sults being indicated by the mode of day examination. The lower
flectors especially appeared inoperative, not merely because only a
ttle light could in any case fall upon them, but because, if a good lamp
d been in the centre, the adjustment of the reflectors was out. A like
ndition of matters was indicated when at the North Foreland.

Of the two lights at Whitby, within 258 yards of each other, the north
ht lamp is much better than that at the south light. It gives a higher
me and burns more oil, and the appearance at sea corresponds to this
fference. But besides that, there are differences in adjustment. An
cursion to sea at night, on the 9th, was made, and at a given signal
e whole of the lenticular band of the north light was covered up, only
e reflectors being left, to compare with the whole of the south light
a standard. In this state the north light was nearly equal to the
uth light in brilliancy, and in certain positions of the ship was quite
ual to it. The light was thus covered up and uncovered again, twice,
d the observations were made at distances of four and seven miles.
ey showed that the upper reflectors at this house were well adjusted
cast the light upon the sea. Here, therefore, (at Whitby,) it appears
me it would be best to make any proposed changes, for they could be
rried out at the south light-house by Mr. Chance, the maker of the
paratus, who was present, and who understands every point in the
tter, and the north light could be left as a standard by which to
timate the improvement gained.

I am persuaded that the condition and character of the lamp has a
st important influence over the results that have been and are to be
quired. Some persons call a flame 3½ inches high, which I and others
uld consider as only 2½ or 2 inches in the effectual part. Some
sons count from the top of the burner to the top of the tongues of
me, whereas the bright luminus part of the flame often begins ⅝ of
inch above the burner, and, as a body, ceases it may be an inch
even two inches beneath the top of the longest smokeless tongues.
e difference in the consumption of oil at the different light-houses
ows the great diversity existing among the flames of different lamps;
which, if one common standard of adjustment in respect of the optic

apparatus be applied, it must as often be wrong as right. It appea to me that the first thing is to have an excellent and constant lam and that *all light-houses* of the same order should have a lamp of t same quality; that the glass chimney employed should have a gradual rounded shoulder, and not a sharp square one, which greatly distur the direction of the light; that when the best form has been attained should be adhered to; and that the glass and iron chimney togeth should be continuous for 6 feet. Then the practicable constant si and condition of the flame of such a lamp should be determined, and general gauge and measure of the bright part of it and its position relation to the burner be supplied to each light-house, (which cou easily be done by an outline drawing on open wire gauze, or otherwis that the keeper may report whenever the lamp falls short of its quired duty. Having such a lamp, it should be ascertained wheth the foci for the adjustment of the optical apparatus at present adopt are the best for it, as the French authorities believe, or whether th could be advantageously altered; and then apparatus constructed future should be made in conformity thereto, and finally tested in th place by the Royal Commission process.

If Mr. J. Chance were authorized to procure such a lamp for the Sou Whitby light-house, (that is, a lamp which being excellent could be eas and certainly repeated,) and were then to adjust the optic apparatus it, the result could easily be tested by a comparison with the unalte north light, but it would be desirable to be able to ascertain separate as far as may be, the effect due to the improved lamp, and that due the readjustment of the glass.

With respect to the North Foreland light-house, M. Sauter, manufacturer, met the Royal Commission and the Trinity Board the and heard and saw all that passed. I understood him to admit fre the principle advocated by the Royal Commission, but to assert that apparatus was in perfect adjustment for a *proper lamp.* Setting up gauges at the burner, according to the focal places assumed and adop in France, the apparatus, with the exception of one or two prisms, c tainly was in beautiful adjustment to them. For my own part, I am opinion that, in relation to the generality of lamps as I have seen th burning, the foci (at least of the lenticular part) are taken too hi The chief focus at the North Foreland has been placed 28 millimet above the burners. As I saw the lamp burning on the evening Wednesday the 8th instant, and the keeper said it was in its right usual state, the chief plane of light was not above 22 millimeters ab the burner, and if account be taken of the dip of the sea horizon, wh is here about 14′.2, the burner ought to be raised on that account 4 limeters more, making the distance below the focal plane 18 millime only instead of 28. If, however, the lamp were raised enough for correction of this difference, it would greatly throw out of adjustm both the upper and lower reflectors.

M. Sauter is of opinion that the apparatus requires no adjustm but is correct for a proper overflow lamp. He has full confidence in French authorized foci. He is, however, ready to raise the lamp an readjust the reflecting prisms to any degree the Trinity House may quire. Though I think that the foci may perhaps be altered with adv *tage,* and intend making an investigation of their places when a g standard lamp is employed, if the Trinity Board desire it, I am not prepared to go hastily in opposition to the conclusions carefully drawn from theory, experiment, and long practical application by the authorities in France, and, therefore, am of opinion that if MM. Sauter and Wilkins place a proper lamp in the light-house, and leave it and the optical apparatus in that state of adjustment which the former approves of, and will be responsible for, the determination of any further change there may remain until after the effect has been ascertained of the alterations at Whitby, the changes at the North Foreland itself, and the re-examination of the places of the foci.

M. FARADAY.

REPORT ON FOCAL POINTS.

ROYAL INSTITUTION,
September 1, 1860.

In reference to the examination (proposed at the end of my report of the 16th August, 1860) of the focal points heretofore adopted in France and also in this country, I have to state that from considerations founded upon the size of a good lamp flame, I came to the conclusion that the focal point for the lenticular or dioptric part was right, or very nearly so, but that those adopted for the upper and lower reflectors were much too low. Those for the lower reflectors may be represented by a common intersecting point, 10*mm.* above the burner, and 48*mm.* from the axis on the side towards the reflectors. My first judgment was to alter this point, by raising it so that it should be 20*mm.* above the burner, and 50*mm.* from the axis. Mr. James Chance invited me to see two fine first-class lights for Russia, one of which, being a fixed light, he had of his own judgment and experience, adjusted to foci different to the above. I found the effect of this alteration to be very excellent, and I found, moreover, that his numbers and mine were so near to each other as to render them, in effect, coincident. I consider the result, therefore, a full practical confirmation of the numbers, and I do not hesitate to recommend this alteration for the adoption of the Trinity House.

With regard to the upper reflectors, my preliminary judgment was for a far greater change. The French authorities (which we in England have thus far followed) is for a common focus for all the upper reflectors placed in the axis of the flame, and raised 38*mm.* above the burner. I think the common focus ought to be 27*mm.* above the burner, and 32*mm.* from the axis on the side from the reflectors. I have endeavored experimentally, with a good lamp, to establish or correct this estimate, and my results gave a point 30*mm.* above the burner, and 32*mm.* aside from the axis as an excellent place; but I desire to carry out this change upon a whole panel of upper reflectors before I recommend it finally to the Trinity Board.

M. FARADAY.

To P. H. BERTHON, Esq., &c.

REPORT ON EXPERIMENTS AT MESSRS. CHANCE'S WORKS AND AT WHITBY IN RELATION TO FOCAL POINTS.

ROYAL INSTITUTION, *September* 14, 1860.

I have been to Birmingham, and worked for two days with Mr. Jame Chance upon the determination of the best focal points for the uppe reflecting prisms. I still see reason to expect much improvement by th change referred to in my report of the 1st instant, and now propose t carry out that change experimentally at Whitby.

For this purpose, I propose (as before) that the north Whitby ligh be left untouched, for a standard. That Mr. J. Chance provide for th south light a good overflow lamp, with a continuous chimney, 6 fe in length from the bottom of the glass, and adjust it so that a ray fro the sea horizon passing through the middle of the lenticular zone sha intersect the axis of the lamp at a point 28*mm.* above the burner. Th the lower reflecting prisms of all the four octants, *save the third*, countin from the north, be adjusted to the sea horizon, from a focus 20*mm.* abo the burner, and 50*mm.* from the lamp axis towards the reflectors. Th the upper reflecting prisms, save those of octant No. 3, be adjusted the sea horizon, but from different foci; the north panel or No. 1, to focus 20*mm.* above the burner, and 30*mm.* from the lamp axis, on t side from the reflecting prisms; panel No. 2, to a focus 28*mm.* above t burner, and 30*mm.* aside; the south panel, or No. 4, to a focus 28*m* above, and 40*mm.* aside. The octant No. 3 to have both the upper a lower reflecting prisms adjusted by the French foci, and not to the s horizon, but to the true horizon.

I then propose to go to sea at night-time, and examine the effect these different adjustments at distances up to 18 or 20 miles, moving some such course as that a plan of which is herewith sent, that t effect of each adjustment may be observed and compared with t north light; and I propose that, at the extreme distance, the lenticul band shall be screened off, so that, in returning, the effect of the refle ing prims *only* shall be seen and compared, the northern light st remaining unchanged.

This sea trip will probably decide the best arrangements, but if cau appears for trial of any other foci, or any other arrangement, su arrangements can be made in a day or two, and a second night exam nation at sea be made.

The expense incurred by the experiments at Birmingham, by th now recommended at Whitby, and for apparatus I have had occasi to order, will probably not exceed £300.

I have, &c.,

M. FARADAY

REPORT ON EXPERIMENTS AT WHITBY IN RELATION TO THE FOCAL POI OF LIGHT-HOUSE APPARATUS.

ROYAL INSTITUTION, *October* 19, 1860

The experiments referred to in the report of the 14th September ha now, by the authority of the Trinity House, been carried out, not o in London and Birmingham, but also at Whitby, and the deputy mast with certain of the brethren, have there entered into an examination of the results.

The south light at Whitby was inferior, on the occasion of the former visit, to the north light, though both lamps were of the same construction. That in the north house was left unchanged, to serve as a standard; that in the south house was changed for one with four wicks, and a plentiful overflow, and the light it now gives is not merely considerably more than before, but more than that of the north light. It has burnt well from the first. The average proportion of oil consumed in a fortnight is 15 pints for the south light and 13 pints for the north light per 12 hours. These quantities accord with the proportion of light which they really give.

In reference to the focal changes and adjustments for the experiments, the following arrangements were made: There were four equal octants or eighths of glass apparatus in the Whitby south light-house, with a central lamp to the whole. Each had its three parts—the lenticular band, the upper, and the lower reflectors. The lenticular part is the most powerful, the upper reflectors come next, and the lower reflectors are last. The adjustment is made, first, by the elevation of the lamp for the lenticular band, and after that by the position of the prisms for the reflector part. The lenticular part is (in the Whitby case) adjusted for all the octants at once. The French focus for this part has been adopted, namely, 28*mm.* above the burner, but the French authorities send the chief ray on a horizontal level for a light of such a height as Whitby, whereas, I have sent it down to the sea horizon. No. 3 octant was selected to represent the French adjustment, but it was impossible, whilst regulating the lenses of the other octants, to separate this from them, so that it had an advantage in the comparison as respects this lens part. As to the reflectors, however, the focus (or common focus) for the upper set is 38*mm.* above the burner in the axis of the flame, and 9*mm.* up and 50 aside for the lower set. These were adjusted accurately in the light-house to the *true horizon or dead level.*

The other octants had each a pair of common foci for the reflectors, as follows:

No. 1 (D) 20*mm.* up and 30 aside upper reflectors and (I) 20 up and 50 aside lower reflectors.

No. 2 (E) 28*mm.* up and 30 aside upper reflectors and (I) 20 up and 50 aside lower reflectors.

No. 3 (G) 38*mm.* up and 0 aside upper reflectors and (K) 9 up and 50 aside lower reflectors, (French.)

No. 4 (H) 28*mm.* up and 40 aside upper reflectors and (K) 9 up and 50 aside lower reflectors.

The octants 1, 2, and 4 had their adjustments made to the *sea horizon.*

The intention of all these arrangements was to discover and establish (what was expected on principle) that much light, hitherto thrown up into the sky, might be disposed of on the sea between the distance and in shore without any diminution of the light on the sea horizon, and that if particular regions in certain directions short of the horizon required an especial amount of light, what special or common foci were proper for such a purpose.

The night sea voyage was so arranged that, by turning the apparatus, the various octants (with all the light on) could be observed at different distances as the ship went out, the effect of the change from the one to the other being remarked, and at the same time a continual comparison with the unchanging north light being made. On returning towards land the lens part of all the octants was blinded, so that a like comparison of the reflectors, *without the lenses*, could be made over the same series of distances.

When in shore, *i. e.*, about a mile or a mile and a half off, the octants 1, 2, and 4 surpassed the French octant, as was expected. The same effect continued when further out, but diminished in proportion. At 10, 12, and 14 miles out the difference between the octants diminished, but the French octant never surpassed No. 2 or No. 1, and was, as some thought, rather beneath them. The constant north light was most important in helping to settle these differences. When the lenticular bands were screened off, the reflector bands alone gave bright light, but there were differences of the same kind as those already described, though *greater* in proportion.

Every one present made their observations for themselves, but, I believe, with a like result. I had expected No. 2 to be a best if not *the* best arrangement, and I am happy to believe the deputy master and brethren came to that conclusion, since they directed that it should be the type and pattern of adjustment for all the octants of both the Whitby light-houses.

Like observations to those just described had been made on shore, and with the like result, but we had not then the same advantage of observing at very long distances, nor that of comparing with the standard north light.

On the Monday we wrought at the light-house for the purpose of verifying or correcting the focus for the *lower reflectors*. Mr. James Chance, in making the adjustments, found that numbers varying somewhat from those I had given, and even more from the French numbers, caused the rays to be more parallel, and, as they were to supply the sea horizon, such paralellism would be an advantage. The numbers were (L) 25*mm.* up, and 40 aside. (These numbers were used on the night of the sea observations.) By trial I became satisfied of the reality of the advantage, and recommend these numbers to be adopted for the lower reflectors.

All the time we were at Whitby (eight or nine days) Mr. Chance and myself were occupied in learning, practising new methods of adjustment and correction, and using new instruments; and I cannot say too much, in thanking Mr. Chance for the earnest and intelligent manner in which he has wrought with me in the experiments, working and thinking every point out. The method of adjustment is now so perfect that the authorities can hardly require more accuracy than the manufacturer can ensure. The Trinity House may direct, at its pleasure, that the light of one part of an apparatus shall be thrown chiefly in one direction, as the sea horizon, and that of another part in another relative direction, as nearer to the coast, and I have no doubt that if the electric light or any other of the compressed intense illuminations be hereafter adopted, the principles and methods of adjustment now devised and carried into practice will prove of very great and special advantage.

M. FARADAY.

* * * * * *

PORT OF EXPERIMENTS AT BIRMINGHAM ON THE FOCAL POINTS OF THE LENTICULAR PANEL OF A FIXED FIRST-ORDER LIGHT-HOUSE APPARATUS.

ROYAL INSTITUTION, *December* 3, 1860.

I have been engaged at Birmingham for three days (26th, 27th, 28th vember) with Mr. James Chance, in ascertaining for each particular of such a panel as that referred to above, the best point or points in lation to the burner from which the rays should issue, that the maximum illumination might be at the horizon; and also testing by prac- ce the method proposed by Mr. J. Chance of adjusting the ribs to each her and to the lamp, so that they should coincide in their action.

A fixed-light lenticular panel consists of a chief broad middle band, d of other bands or ribs above and below it, forming two groups, nerally nine in each. These, when associated in the panel frame, ve, according to the accepted rule, their common focus at 28*mm.* ove the burner of the lamp.

The relation of the flame and burner to the upper and lower parts of e lenticular panel is the same in kind, though not in degree, as their lation to the upper and lower reflectors. Thus, the opaque burner, hich hides much of the flame from the lower reflectors, also hides ame from the lower part of the lenticular panel, though not in the me degree; but as the lenticular panel is a very chief part of the paratus, any desirable correction which can be made amongst its arts, if possible, becomes of importance.

Using a flame, such as that represented in the report of the 19th Octo- er, 1860, in conjunction with a panel of the kind described, and cast- g the light passing through each rib separately in a perfectly hori- ntal direction, we found that the best focal point for the middle or hief rib was 20*mm.* above the burner at the axis; that the upper ribs, ough varying one from another, might have the same points of 20*mm.* ken for their average or common focus; and that the lower ribs quired much higher focal points in the axis, varying from about 18 to 0*mm.* above the burner, all of which might be referred to a common cus, 11*mm.* up and 36*mm* aside towards the panel.

Supposing that these numbers (or any other) were determined upon, hen the possibility of adjusting the parts of the panel to each other ame to be considered; without which possibility it would not be right r the authorities to require that a finished panel should be subject to amination by the focimeter, in relation to such given points. The bs of a lenticular panel cannot be adjusted to each other by any rota- on of them on a horizontal axis, as is the case with the ribs of a flector panel, but only by elevation or depression in respect of each her; and now Mr. Chance proceeded to show me how, by ascertain- g the best focal point for each rib and their relation to the focal point the great central rib, he ascertained how much they were in error; d then what proportion of glass would require to be removed from e broad bearing surface of this or that rib to bring the whole into arest approximation to the desired position. This he carried into fect with the panel which we had had under examination, and which d been constructed in the ordinary way, and without any particular ew to such a correction; and the consequence was that a panel was oduced, which, when set up with the focimeter upon the burner at the numbers given above, and a small flame upon the distant (107 feet dead level for each rib, gave a perfect practical result. The spac between the green and red light was the part of the flame observed and the error for any rib was not more than 1*mm.*, except in two case out of nineteen, in which it did not exceed 2*mm.* When the great lam was lighted the effect was in accordance with the expected result The coincidence of all the rays in one common maximum could only b observed at a great distance, *i. e.*, at the dead level horizon; but eac rib could be examined for itself and for the dead level of that rib.

It must be thoroughly understood that the focal numbers have rel tion to the flame of the great lamp. As before stated, the higher an more powerful the flame, the greater height should the focal distanc be above the burner; but even with a very high flame we do not fin that the focal point of the middle belt and upper ribs can be raise higher than 23 or 24*mm.* above the burner, without sending the brighte light to the sky. The character and size of the flame differ very mu at times, and even with the *same* flame persons differ very much their estimate of its magnitude, and the place of its brightest pa We have taken a flame corresponding, as far as I can judge, with th figured in the report of the 19th October, 1860. It is easy to obtain higher flame by close attention and for a short time; but I do not thi that a higher one is often sustained in light-houses.

In respect of the "Smalls" light, therefore, I recommend a focal poi for the central and upper ribs of the lenticular panel of 20 (or 21) *m* above the burner; and for the lower ribs a point 11*mm.* up and 36*m* aside in relation to the dead level, and a further correction of 3*mm.* the dip to the sea horizon.

The final examination of an optic apparatus for light-houses can o be carried on, with the degree of accuracy which I have described, the manufactory, or at a place arranged with all appliances for purpose, or at the light-house (when in place) when there is a g clear sea horizon. In the case of the "Smalls," no difficulty will occ since the apparatus is already in the hands of Messrs. Chance.

Perhaps it may be agreeable to the Trinity House to be inform that the changes proposed now and formerly are all in accordance w observations made by the Astronomer Royal at Messrs. Chance's in beginning of the year, and which he communicated to me personally April last.

M. FARADAY

ADJUSTMENT OF APPARATUS.

The following correspondence with the Commissioners of North Light-houses shows that, previous to the investigations of the Lig house Commissioners, the engineers employed by the Scotch Board h not made any adjustments of the burners of dioptric lights with ref ence to the height of the light above the water:

ROYAL COMMISSION, LIGHTS, BUOYS, AND BEACONS,
7, *Milbank street, London, December* 1, 1860

SIR: The Commissioners have received a report from the Astronom *Royal* of his visit to Girdleness; also a copy of Mr. Thomas Stev son's report of that visit; as, also, of his (Mr. Stevenson's) visit to Whitby and the North Foreland. The Commissioners have also before them Mr. Thomas Stevenson's work on Light-house Illumination, 1859, second issue, and the replies he has been so good as to send to printed questions sent to him by them, and also Mr. Alan Stevenson's Rudimentary Treatise, 1860. In the first of these works, Mr. Thomas Stevenson speaks (pp. 78, 79) of a "dipping light," and he appears to think it suitable for high light-houses, and in fogs, to direct the rays, ordinarily directed to the horizon, to points nearer at hand. He proposes that the apparatus should be hinged, and moveable under the control of the keepers. Mr. Alan Stephenson proposes (pp. 70, 124) that in very high light-houses the "lenses should have a slight inclination outwards, so as to cause the most brilliant portion of the emergent beam to reach the visible horizon which is due to the height of the lantern."

In page 126, Mr. Alan Stevenson says: "In other cases where the whole horizon has to be illuminated, and great vertical divergence is at the same time desirable, a slight elevation of the burner, at the expense, no doubt, of a small portion of light, is *sometimes* resorted to, and is found to produce with good effect the requisite depression of the emergent rays."

The distance prescribed by Fresnel for the burner of a first-order dioptric light to be placed below the focus for parallel horizontal rays is 28*m*., or 1.1 inch. In a first-order dioptric light, placed at a height of 185 feet, (Girdleness,) the dip due to that height being 15′ 37″, and the tangent for the focal distance of that angle being 3.5*m*., the image of the horizon would be looked for and would be expected to appear at 28*m*. + 3.5*m* = 81.5*m*., or 1.23 inch above the burner.

The Astronomer Royal states that he found the image of the horizon $\frac{3}{8}$ inch too high, or at 1.6*m*. above the burner, and that he recommended the lamp to be raised half the error or $\frac{3}{16}$ inch. The upper and lower prisms appeared to be well adjusted to the erroneous position of the lamp, and the Astronomer Royal recommended, therefore, that the lamps should only be raised $\frac{3}{16}$ inch, or one-half of its error. It would probably affect the adjustment of the upper and lower prisms if the lamp was to be accurately placed. It would appear, therefore, that the burner at Girdleness was *lower* even than Fresnel's position by 0.25 inch, (one quarter of an inch,) and not higher, as it should have been, by 0.13 of an inch.

No conclusion, however, can be drawn from the experiments as to whether or not the lamp at Girdleness was originally adjusted to the visible horizon, because the burner appears, from Mr. Stevenson's report, to have been replaced without supervision.

Conversations with Mr. Thomas Stevenson have left an impression on the minds of the Commissioners (but they may be mistaken) that in no illuminating apparatus *designed by him* has he ever intentionally adjusted the lamp or apparatus to the height of the light above the water, or displaced the position of the lamp, as prescribed by Fresnel, viz., the burner to be 1.1 inch below the focus for parallel horizontal rays, in first-class dioptric lights.

The Commissioners desire to be informed, first, what was the original position of the burner as regards the focus of the lens referred to in each of the first-class dioptric lights erected by Messrs. A., Thos., and Stevenson, and by the late Mr. Stevenson in Scotland; and second, furth in detail, what course, if any, the Messrs. Stevenson adopt in adjusti the position of the lamp, with reference to the said focus, to the heig of the light above the water, naming the lights in which this adjustme has been made, and its amount in each case; also, third, what cour if any, they adopt, if they make the above adjustments, in making t further adjustments of the *lower* prisms, so that their said foci may n be in the metal burner when the lamp has been raised considerably consequence of the light being a considerable height above the wat and also naming the lights in which the adjustments have been mad and also, fourth, what course they adopt in the above case in adjusti the *upper* prisms, that their foci may not, when the lamp has been cons erably raised, be in a different section of the flame from that previou selected by Fresnel, naming the lights in which the adjustment l been made; and also, fifth, whether in any case they have altered t position of a lens or prism after the illuminating apparatus has b erected at a light-house, and if so, in what cases and for what reaso also, sixth, what precautions are taken when old burners are repla by new burners to ensure the correct position of the flame being ac rately preserved.

I am, &c.

NORTHERN LIGHT-HOUSE OFFICE,
Edinburgh, December 10, 186

SIR: I am directed by the Commissioners of Northern Light-hou to acknowledge the receipt of your letter of 1st current, transmitt various queries as to the practice of Messrs. Stevenson in regard to lamps prepared by them. Having laid this before the Commission they directed me to communicate it to Messrs. Stevenson, and I am i instructed to forward a copy for their answer.

I am, sir, your most obedient servant,
ALEX. CUNNINGHAM,
Secretar

The SECRETARY ROYAL COMMISSION ON LIGHTS, &c.

EDINBURGH, *December* 7, 186

DEAR SIR: We have received the letter addressed to the Commiss ers by the Royal Commission on Light-houses, dated 1st December. 1 and we have, as requested by you, to make the following replies to queries therein contained:

1st Query. What was the original position of the burner as reg the focus of the lens referred to in each of the first-class dioptric li erected by Messrs. A., T., and D. Stevenson, and by the late Mr. Ste son in Scotland?

Answer. In all of the light-houses erected by Messrs. R. A. D. an Stevenson, the burner of first-class dioptric lights was originally pla *in the* position shown in the engraved diagram, which is hung u the light-rooms for regulating the position of burner and size of flame. In that diagram the top of the burner is 1 1/16 inch below the plane of the focus.

2d Query. Further in detail, what course, if any, the Messrs. Stevenson adopt in adjusting the position of the lamp with reference to the said focus to the height of the light above the water, naming the lights in which the adjustment has been made, and its amount in each case?

Answer. Messrs. Stevenson have not made any adjustment of the burner of dioptric lights with reference to the height of the lights above the water. The highest of the dioptric lights in Scotland is 346 feet, and it was not considered necessary in these cases to adopt any special adjustment. But the necessity for such an adjustment when the elevation was great was recognized by Mr. Alan Stevenson, in his "Treatise on Light-houses," and was adopted by the late Mr. Robert Stevenson in the high catoptric lights, such as Barrahead, where the reflectors are dipped.

3d and 4th Queries. What course, if any, they adopt, if they make the above adjustment, in making the further adjustments of the *lower* prisms, so that their said foci may not be in the metal burner when the lamp has been raised considerably in consequence of the light being a considerable height above the water, naming the lights in which this adjustment has been made; and also, fourth, what course they adopt in the above case in adjusting the upper prisms, that their foci may not when the lamp has been considerably raised, be in a different section of the flame from that previously selected by Fresnel, naming the lights in which the adjustment has been made?

Answer. For the same reason, no special adjustment has been made of the upper or lower prisms.

5th Query. Whether in any case they have altered the position of a lens or prism after the illuminating apparatus has been erected at a light-house, and if so, in what cases and for what reasons?

Answer. No alteration has been made after the final adjustment of the light.

6th Query. What precautions are taken, when old burners are replaced by new burners, to ensure the correct position of the flame being accurately preserved?

Answer. The only precaution which is taken in renewing burners is the employment of careful workmen, and the inspection of the foreman of light-house repairs, whose duty it is to see that the position of the burner is conformable to the engraved diagram.

In further explanation, we have to state, that in all cases the apparatus is carefully inspected and tested before it leaves the workshop; and that, before a new light is considered as finally adjusted in the light-room and ready to be exhibited, observations are made upon it from the sea at various distances and in various azimuths, when any imperfection that may be detected is rectified.

We are, &c.,

D. & T. STEVENSON.

A. Cunningham, Esq.,
Secretary Northern Lights Board.

LATER OBSERVATIONS ON THE MAGNETO-ELECTRIC LIGHT AND STEAM FOG-SIGNALS.

Observations by Dr. Gladstone.

Since the oral examination of Professor Holmes, I have visited his works at Northfleet. The electro-magnetic machine there is a smaller one than that used at the South Foreland light-house, but the lamp is a great improvement on that previously employed. It appears to resemble in principle the lamp of M. Serin, which he exhibited to me at Oxford last July. It seems simple in construction, and certainly gave a beautifully steady light, without the necessity of any attention. The only fluctuations in the intensity of the light were probably due to the presence of iron, or some other imperfection in the carbons. By means of the refracting goniometer I made a prismatic analysis of the light, and determined the following points, which have some bearing on light-house illumination:

1st. The light presents a continuous spectrum, that is, it includes rays of every refrangibility, and that throughout a range exceeding the range of bright sunshine in England, both at the red or least refrangible and at the violet or most refrangible end. The character of the light closely resembles that of the sun, but with a larger proportion of violet.

2d. A thick sheet of Mr. Chance's red glass placed before the lamp was found to produce a beautiful red light. On analysis, this was found to consist of a very large amount of red and orange rays, with a small quantity of green and blue.

3d. Sheets of green and blue-green glass from Mr. Chance's works gave rise to green and blue-green lights. Cobalt blue glass produced a purple light, with great reduction of the luminosity, and not so striking a modification of the color as to render it advisable to employ it as a means of distinction. Cobalt glass also has this serious disadvantage for light-house purposes, that a bright light seen through it might be altered by a fog from purple to red.

4th. Much violet light of high refrangibility is emitted from the carbon points. As such light is known not to pass freely through glass, I particularly examined whether it formed so large a proportion of the rays as to render thick dioptric apparatus objectionable, and to incline the experimenter to turn his attention to apparatus arranged simply on the principle of reflection. I found, however, that the interposition of a piece of good plate glass, about an inch thick, produced little sensible diminution of the light thrown on a sheet of white paper held at various distances. By special contrivances with the prism, however, I was able to determine that this glass did make a difference on the extreme violet rays, but so slight that it may fairly be disregarded. The light seen at the distance of a mile on a clear night still exhibited a violet ray, of a refrangibility scarcely known in sun light, notwithstanding the absorbent effect of the atmosphere on such rays.

The magneto-electric light is perfectly continuous, and not a rapid succession of sparks.

Professor Holmes exhibited it also in one of the large reflectors that he proposes for revolving lights. These as yet are somewhat roughly made, and their reflecting surface is tin-foil and not silver; but the elipse and parabola are made with considerable approach to correctness, and the apparatus was fully capable of demonstrating practically that by this means Mr. Holmes is able to bring all the rays emitted from the carbon points on to a space subtending only a few degrees, and to cause very few rays to be sent to the sky, while the sea and the horizon are brilliantly illuminated. The whole apparatus revolving will cause the horizon to be illuminated in every azimuth by turns, and the light is not a waxing and waning one, but commences and terminates with a flash. There is another reflector, contrived so as to give a series of flashes during the period that the light remains in view, but the effect of this was not practically exhibited.

The effect of the light shining in the focus of an ordinary silvered parabolic reflector was exhibited at night. The brilliancy of the illumination obtained at the distance of a mile was surprising, and the beam from the mirror was comprised within very small limits, not many paces.

Steam trumpet.
Fog-signals.

Professor Holmes exhibited his steam trumpets also, which he proposes for use as fog-signals. My attentien was first attracted by the noise when within a hotel more than a mile distant. It was subsequently found that the origin of the continuous sound had given rise to many conjectures among the inmates of the said hotel. At the works there are three of these instruments, the construction of which was explained, and which require but a small quantity of steam to produce the sound. A steam whistle, also on the same premises, requires a much larger quantity of force to work it, and produces less noise. The trumpets can be tuned at will, and so made as to produce whatever note is found to be heard at the greatest distance. When one of them was blown in the direction of the Thames, and the steam suddenly turned off, a double reverberation was heard from the hills on the other side of the river.

J. H. GLADSTONE.

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ELECTRIC LIGHT.

FURTHER REMARKS BY THE ASTRONOMER ROYAL ON THE ADOPTION OF THE MAGNETO-ELECTRIC LIGHT.

ROYAL OBSERVATORY, GREENWICH,
London, S. E., April 9, 1861.

MY DEAR SIR: I have perused the evidence of Professor Holmes, given to the Commissioners on January 2, and have been much interested with it. It proves beyond doubt the practicability of the application of the magneto-galvanic light to all the purposes of light-houses for illumination of the distant horizon, for illumination of the near sea, and for the purposes of revolving lights. In regard to the last, I am surprised that any difficulty has presented itself. The galvanic light is as applicable to revolving lights as to fixed lights, requiring only pretty good mechanical workmanship in the rotatory parts.

In some of the optical explanations given in the evidence to which I allude, there is a little inaccuracy. Thus, the rule given for the adjustment of the central lens in the answer to question 610 is erroneous; the position of the inner surface as reflecting back the light being very unimportant, while in reality all depends upon its elevation with reference to the elevation of the lamp. And the rules for adjusting the prisms are not perfectly accurate.

In fact, I found, by internal inspection of the South Foreland high light-house, and also by external comparison of the light of the high light-house with that of the low light-house, that the optical parts of the high light-house even now are ill adjusted, though probably in a better state than before Professor Holmes examined them.

I entirely agree with Professor Holmes in his strong condemnation of the selection of the Dungeness light-house as a place for trial of the magneto-galvanic light. It is certainly the worst station for that purpose (except, perhaps, the Spurn) in the whole circumference of Britain

I am, my dear sir, yours very truly,

G. B. AIRY,

Admiral W. A. B. HAMILTON, &c.

ELECTRIC LIGHT TO BE USED IN FRANCE.

The following paragraph states that the French Government are about to use the electric light to some extent.

The Commission have no time to inform themselves of the facts, but they reprint the paragraph in order that attention may be drawn to the subject:

"The Minister of Marine has decided to establish eight electric lights on the coast of the department of the Seine Inferieure. These eight lights are to be placed at Cape de la Heve, Cape Antifer, Etretat, Fecamp, St. Valery-en-Caux, the point of Ailly, Dieppe, and Treport. The object of these lights is to maintain a communication with ships within sight of land, and to transmit the news rapidly to the interior. A contract was concluded at the Marine Office, at Havre, on Saturday last for the construction of these eight lights."

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CIRCULAR NO. IX.

ROYAL COMMISSION ON LIGHT-HOUSES, &C.

Questions for Scientific Men.—No. 1.

7, MILLBANK STREET,
Westminster, S.W., 1860.

The Commissioners appointed by the Queen to inquire into the condition and management of lights, buoys, and beacons, namely: William Alexander Baillie Hamilton, Esq., Rear-Admiral, R. N.; Alfred Phillipps Ryder, Esq., Captain, R. N.; John Hall Gladstone, Esq.; Duncan Dunbar, Esq., Chairman of the London Local Marine Board; and Samuel Robert Graves, Esq., Chairman of the Liverpool Local Marine Board; are anxious to obtain the opinions of scientific men on certain points connected with their inquiry, and to publish the evidence in their report. They will be obliged if you will reply to such of the following questions as relate to subjects which you have specially studied. They request that your answers on this paper may be short, and if you desire to give any more extended explanation of your views, that you will give it separately, in writing, or refer to any work which contains the information.

I have the honor to be, your obedient servant,

J. F. CAMPBELL,

Secretary.

OPTICS.

Production of Light.

I. The evidence of, (here be kind enough to write your name, &c.)

II. In light-houses and floating-lights which are *easy of access*, do you think that there is any method of producing light better than burning oil to the best advantage? If so, describe in a few words the method to which you refer.

Gas is used in some harbor lights. The magneto-electric light has been under trial for some time at the South Foreland, and several other inventions have been proposed. Send separately any detailed information which you may wish to give as to comparative cost, &c.

III. Taking into consideration the difficulty of transport to light-houses and floating-lights in isolated and remote positions, and the danger which results from an accidental extinction of such lights, do you think that the method you have referred to could safely be substituted for oil in light-houses and floating lights so situated?

Utilization of Light.

IV. *Revolving Lights, &c.*—What optical arrangement do you consider best for showing to an observer placed on the horizon, or at any point within it, for short periods, recurring at intervals, the greatest possible quantity of the light produced by the combustion of a given quantity of oil, or by any other given method?

Metallic and other reflectors, polyzonal lenses, ground, and the same cast, totally reflecting prisms, and combinations of these, are used, or have been suggested.

V. *Fixed Lights.*—What optical arrangement do you consider best for showing continuously and simultaneously to observers on the horizon, and at any points within it, the greatest possible quantity of the light produced by the method to which you have referred?

VI. Do you consider the methods which you have described applicable to floating-lights, with or without modifications?

If with modifications, describe them in a few words, or separately at length.

VII. Please to send any suggestions which you may wish to make relative to—

a. The manufacture of reflectors, including materials and shape.

b. The manufacture of glass.

c. The manufacture of lenses and prisms.

d. The placing of optical apparatus in light-houses, so as to use the light produced to the best advantage, having due regard to the position and elevation of the light.

Color.

VIII. Can you suggest any means, other than the interposition of colored glass, for producing servicable colored lights?

IX. Have the goodness to send separately any suggestion that yo may wish to make relative to—

a. The manufacture of colored glass.

b. The placing of colored glass with refererence to the light.

Colored chimneys, glass screens within the lens, the same outsid colored panes in lanterns, and combinations of these plans, have bee tried or proposed.

X. *a.* Which colors can, in your opinion, be seen at the greatest distanc *in all weathers*, and at the same time can be most easily distinguishe from each other, and from white light?

b. Is white light, or some colored light, in your opinion, most servic able in a fog? If the latter, what color?

XI. *Distance.*—Do you know any method by which the distance fro a light may be determined, when sailing directly *towards* it, when yo can see it from the deck?

a. When the height of the light above the water is known.

b. When the height in not known.

MECHANICS.

XII. Can you suggest any improvements in—

a. The construction of light-houses in exposed or other situations?

b. The construction of beacons in similar positions?

XIII. Can you suggest any improvements in the constructien of lamps, revolving apparatus, or other mechanical appliances now used in light-houses and floating-lights?

FLOTATION.

XIV. *Floating Lights.*—What, in your opinion, is the best form for the hull of a floating light? That is to say, a vessel intended to ride at anchor in all weathers, in exposed situations, in strong tides, and heavy seas, with the least possible movement, and the least possible strain on the moorings.

Some light-vessels are longer, some shorter, some have more shear than others, some have bluff bows, others are sharper. Sometimes, owing to tide or current, they do not ride head to sea, and the movement is often excessive. It has been suggested to build them of a circular form, to be moored by the centre of gravity.

XV. *a.* Can you suggest any improvement in the present mode of mooring light-vessels?

b. At what part of the vessel would you advise that the moorings should enter?

In some cases the hawse-holes are at a considerable height above the water, in others close to the water line, and it has been suggested to place them under water.

XVI. *a. Buoyage.*—Which of the forms now used or proposed for buoys do you think best for riding in all weathers, in exposed situations, in strong tides and heavy seas, with the least possible strain on the moorings, and so as to be conspicuous; or can you suggest any improvement in the form of buoys, or the method of mooring them?

b, What description of buoy would you recommend for sheltered situations?

c. Can you suggest any serviceable method of rendering buoys luminous at night?

XVII. *Buoyage system.*—Can you suggest any system generally applible for buoying coasts, harbors, rocks, shoals, and channels, so that, even in the absence of pilots, and without the aid of a chart, vessels might be safely navigated? If so, have the goodness to describe it, and to state whether it is applicable to buoys now in use.

ACOUSTICS.

XVIII. What description or pitch of sound is most capable of penetrating a fog? What method do you consider best for producing such a sound?

XIX. What description of fog-signal would you recommend as the most serviceable?

Gongs, bells rung by machinery, and guns are used, as also reflectors and other contrivances for directing and condensing sound. Mechanical and steam whistles, &c., have been suggested.

XX. What method do you think best for concentrating sound, or for throwing it in particular directions? Do you think that any method would enable mariners to distinguish with sufficient certainty the direction from which a sound proceeds?

XXI. At what altitude should fog-signals be placed, so as to be heard at the greatest possible distance?

METEOROLOGY.

XXII. What is the elevation at which it would be desirable that lights should generally be placed on the coasts of the United Kingdom, having regard to these facts, viz: the higher the light the greater the distance to which the rays will reach before they are intercepted by the horizon; the lower the light the less likely it is to be obscured by clouds?

XXIII. Supposing the telegraph to be extended to certain light-houses and light-vessels at salient points of the coast, what is the meteorological information which it would be most desirable to transmit to passing ships, and how and in what form could it be most readily received and communicated by light-keepers?

XXIV. *Tide Signals.*—What system would you recommend for general adoption, in connection with light-houses at the entrance of harbors, for indicating the state of the tide, by day and by night, to persons in the offing?

Various systems are now in use, including balls, flags, colored lights, illuminated figures moved by the tide, &c., and others have been suggested.

XXV. *a.* Are you aware of, or can you suggest, any good system for identifying light-houses and floating-lights by day?

b. Can you suggest any improvement in the system now used for identifying them by night?

CIRCULAR No. X.

Questions for Scientific Men, Manufacturers, &c.—No. 2.

SIR: I am directed to state that the Commissioners would be greatl obliged to you for any replies that you may be disposed to give to th following questions.

I am, &c.,
J. F. CAMPBELL,
Secretary.

I. Would it, in your opinion, be of advantage, in constructing dioptri and catadioptric illuminating apparatus for light-houses, if the manu facturer were in all cases informed on receiving an order—

a. What is the exact height above the sea at which it is intended t place the light? and,

b. The precise horizontal arc intended to be illuminated?

II. Is it, in your opinion, important to the efficiency of the apparat that this information should be furnished to the manufacturer befo the lenses, prisms, &c., are made and ground, and before they are final adjusted in their metal frames, and before their ultimate position wi reference to the lamp is decided on?

III. Would it be possible to prepare a table from which the ang required for constructing an apparatus to illuminate a given horizon arc, and to be placed at a given elevation, could be readily calculat by the manufacturer from data furnished by the person giving t order?

IV. Are any such data (so far as you are informed) now furnished light-house authorities to the makers of illuminating apparatus?

* * * * * *

CIRCULARS NOS. IX AND X.

ANSWERS TO SCIENTIFIC QUESTIONS.

I. Thomas Romney Robinson, D.D., Observatory, Armagh.

II. In general, I consider oil the best. In particular cases intensity may be much increased by mixing a portion of oxygen w the *air* which supplies the Argand burner. If gas be used, its brillian is increased by saturating it with the vapor of naphtha, or better, benzole. Lime light is nearly as troublesome and precarious as t electric, but has only $\frac{1}{100}$ of its intensity. I conceive these *intense* ligh should only be used in case of fog or snow. In ordinary cases, a fir class Fresnel light is visible at any distance within view of a vesse masthead. I have been told that the Skerryvore light has been se from Ben Nevis, about 90 miles. In 1851 I found a dioptric light Pentland Skerries ten times as *intense* as the catoptric on Dunnet He

III. Except in the case of fog, I think oil the best. *Then*, as auxiliary, the magneto-electric light may be used, but its regula should be, like that of Mr. Serrin, able to rekindle the light wh interrupted. For *flashes*, the electric light is less objectionable than continuous exhibition.

IV. Certainly, Stevenson's holophotal combination—a parabolic m ror, with a Fresnel's lens in front to catch the rays which wou escape the mirror; especially, if instead of a triple or quadruple c centric lamp, a smaller flame of more intensity were used.

V. I know of none better than Fresnel's cylindric arrangment with oil. If the electric light be used, as its small size will not allow sufficient divergence, the lenses must be specially figured.

VI. For floating lights, I suppose the simplest arrangements are the best.

VII. *a.* The present process is a very rude one, and gives an untrue surface. Perhaps, if a mould were figured carefully, accurate specula could be formed on it by electroplating.

b. I have no suggestion on this, except that the transparency of the glass should be *measured* before it is wrought into lenses or prisms, and its power of resisting sea air. Some kinds become rapidly tarnished.

VIII. None that are available for this purpose.

IX. *a.* I wish to suggest that it is important to ascertain the character of the light transmitted by colored glasses, for the spectra are very different when the eye sees nearly the same tint: and the absorption by the atmosphere may also be different.

b. As few as possible pieces of glass should be interposed between the light and air. Light is lost at every surface by reflection, and absorbed by every inch of thickness. Three inches of the best flint glass will intercept 0.19 of this incident light.

X. *a.* Undoubtedly red: according to my experience, no other color can be perceived a few miles off. What red medium is best, remains to be determined.

b. I would prefer white: the fog will absorb various rays: any coloring medium will abstract some of the useful.

XI. *a.* If stars are visible, the distance between one near the zenith and the light, taken with the sextant and the time, will give the light's altitude. I know none other available in a sea way, unless *Professor* Smyth's revolving stand comes into use.

b. If the intensities of the light be known, and the distance run, the distances at the time of the two observations are easily found. The intensities could be measured by a simple photometer, a wedge of dark glass slided before a slit, through which you look till the light disappears.

XII. *a.* I should prefer trussed structures of iron, left open to give passage to the waves; painted, not galvanized; and where there is a prevailing set of sea, strongest in that direction.

XIV. Generally speaking, I should prefer a vessel long, sharp forward, and with wave lines, but as flat in the floor as possible amidships, in reference to sea. A circular vessel would, I think, pitch excessively; but the principle of mooring, so that the strain on the moorings should pass as near the centre of gravity as possible, seems good.

XVI. *c.* Near a harbor, buoys might be provided with reflectors of silvered glass, portions of cylinders on which a strong beam of parallel rays might be thrown from shore. With electric light, I am disposed to think this could be done several miles off.

XVIII. I believe fog acts merely as a general damper of sound, and therefore do not think any peculiar pitch preferable.

XIX. A whistle; its pitch to be as discordant as possible from that of the sounds made by the wind and sea. These are said to be generally belonging to C. The flash of a gun would be visible at some distance, but how far is not known.

XX. A large speaking trumpet intensifies the sound, but confines it to a limited divergence. It has been tried with guns, and would undoubtedly act well with a steam whistle. But it could only be of use on a single line of approach.

XXI. As near the sea level as possible.

XXII. Judging from my limited experience, I should say not less than 100 feet nor more than 500.

XXIII. Mr. Wheatstone has recently invented a form of telegraph which can easily be worked and read by the keepers. The information most desirable is, the *direction*, *force*, and *place* of a gale, as also whether its strength is spreading north or south, &c. These could be shown by the flags of Marryat's signals, and fresh signals shown as each despatch was read.

XXIV. The announcement by the same code of signals of the actual depth of water for each half hour. Any person who cannot read such signals ought not to command a vessel.

CIRCULAR NO. II.

FEBRUARY 22, 1860.

I. So much so, that till I read this question, I never contemplated the possibility of such apparatus being constructed without these data.

II. Decidedly so. The height of the station may exercise an important influence on the figure, not only of the reflecting prisms, but even of the lenses. At 200 feet height, the dip of the horizon is 14 minutes, which could not be neglected. The horizontal arc is intimately connected with the intensity of the light, assuming that some holophotal arrangement is used.

III. Such tables must be of double entry, with height and refractive index as arguments. They could be made. But I think it would be far better for light-house authorities to employ some competent mathematician to compute in each instance. The pieces of glass should be first cast, and the indices determined.

IV. I do not know. The only place where I have seen such computations is in Alan Stevenson's work on Skerryvore.

I. James P. Joule, L.L.D., F.R.S.

II. I do not. I think gas apparatus much more liable to accidental derangement. I have strong objections to the use of the electric light, for, whether obtained by the use of a voltaic battery or a magneto-electric machine, it is liable to derangement, and the intensity of illumination varies perpetually and to a considerable amount. The oxyhydrogen lime light is, I believe, less objectionable on these grounds than the electric, but I could not recommend it in preference to oil.

III. Paraffine oil might be used in light-houses easy of access. But as it is almost as combustible as camphine, I do not think it would be safe to use it in light-houses in remote positions.

XI. Two lights might be employed, as suggested by Mr. Fryer. The one being placed at a certain known elevation above the other, the mariner could readily find the distance by the use of a sextant or other means for ascertaining the angle subtended by the lights.

XIV. I think Mr. A. Fryer's suggestion is a good one.

"A paper was read by Mr. Alfred Fryer, entitled 'Suggestions for a new form of Floating Light-ship, and a Mode of Estimating the Distances of Light-houses.'

"Authorities agree that ordinary floating-lights are uncertain, being liable to be drifted from their moorings; they are also frequently injured by storms, and are expensive to maintain.

"As the violent action of wind and waves on a considerable surface is the chief cause of mischief, it is proposed to construct a vessel presenting little surface exposed to their influence. The form proposed somewhat resembles a hydrometer, and the material used is wrought iron, the 'stem' being surmounted by the light-room and lantern, and the 'bulb' containing the dwelling apartments and store-room. The form of the stem is slightly taper, and at its union with the light-room is only of sufficient width to admit a ladder and the body of a man easily. The length, shape, and strength would vary within certain limits by local considerations. The vessel represented in the diagram and model was one hundred and twenty-five feet long, two-thirds being exposed, the one-third submerged. A wide flange, the office of which was to retard and reduce oscillation and vertical motion, was attached to the widest part of the 'bulb.' The disturbance of action twenty feet below the surface of the water was shown to be small. Some little light could be reflected down the stem, which is pleasant when the water was violently agitated by storms. Immunity from the dangers of fire and lightning, and little or no chance of shipwreck or being drifted from the moorings, are advantages not to be forgotten. Ample ventilation could be secured by dividing the stem into ventilating shafts.

"Moderate cost, steadiness during storms, and the great elevation at which the light is exhibited, are the chief advantages.

"It is proposed to construct light-houses, in all cases where it is important that mariners should estimate their *distance*, as double lights. The lower light should be exposed in the same tower at a given distance, say fifty feet, and by measuring the apparent distance of the lights apart, either approximately with the eye or accurately with a sextant, the distance can be at once determined.

"If Mr. Herbert's proposition for mooring a series of floating lights along the English and other channels should be adopted, it is proposed to unite them with each other and with the shore by means of a submerged cable and electric telegraph, so that important information either respecting the light-houses or vessels in distress can be communicated to head quarters without delay.

"Models of the ordinary form and proposed new form of light-ships were exhibited, and on the surface of water being agitated the motion of the former was considerable, while that of the latter was very slight."—*Proceedings, Lit. & Phil. Society, Manchester, No. 8.—Session* 1859–60.

XIX. A distinction of sounds should be made so as to indicate the objects whence they proceed. Thus the steam whistle for steamers, bells for sailing ships, gongs for light-ships, and cannon for light-houses.

XXII. Generally about 20 yards above high-water mark, but it would be desirable to determine the best elevation in each instance by meteorological observations made for the purpose.

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I. C. Piazzi Smyth, Astronomer Royal for Scotland.

II. No. There are a few situations where peculiar facilities exist for burning gas, and that will be cheaper and more easily tended than oil, as long as everything goes right; but if something goes wrong, the immediate rectification may not be within the power of the light-keeper, in the same complete manner that is the case with an oil lamp.

IV. Stevenson's holophotal arrangement or combination of lenses, and totally reflecting prisms; to be made of clear glass, ground and polished.

V. Fresnel's annular lenses and annular totally-reflecting prisms, made of clear glass, truly ground, and well polished.

VI. Without modifications, beyond suiting the *size* of the apparatus to the size and stability of the floating vessel; remembering, also, that this answer refers only to the optical arrangements, and not to the mechanical means of producing rotation which must be employed in No. 4.

VII. *b. c.* Alluded to already under IV and V. All pains should be taken to choose clear transparent glass, without the too usual tendency to green or purple, when looked at edgeways; and all the means of the optician should be employed to grind and polish *true* surfaces. In special circumstances, *achromaticity*, by employment of two kinds of glass, may be studied with advantage.

d. The height of the centre of the light to be regulated above the centre of the lens according to the distance at which the light is wished to be best seen and the height of the light-house. The adjustment once made, should never be altered.

VIII. No.

IX. *b.* Colored chimney objectionable on account of the greater brittleness of colored glass, and the difficulty of getting two chimneys of perfectly equal depth of color, or one chimney perfectly equal all around.

X. *a.* Read Dr. George Wilson on color-blindness.

b. White used intermittently. The fog already reduces the intensity of the light, and if to that you add the obstruction of colored glass, you will lose great penetrating power.

XI. *a.* Yes.

b. Yes.

XII. *a.* This question appears too general, for the Commissioners do not mention what light-house as built, or what project of a light-house, they regard as the most advanced model to be improved on, if possible; or what is the character of exposure to which the building is to be adapted.

XIII. Consult Mr. Babbage, F. R. S., at whose house I have seen some very admirable plans.

XIV. Referring only to angular motions, which I have made a subject of instrumental observation in several vessels, I would say, by all means make the breadth equal to the length, and let these be as large as possible, this being the most certain, if not the only, plan of moderating angular disturbances of the light-vessel in shallow seas.

XVIII. A high note is generally preferable; but inasmuch as there is note-deafness, similar with color-blindness, no one note should be trusted to entirely. On the contrary, there should be a long varying sound, as in horn-blowing, beginning at the highest note, and ending at the lowest note, in full volume, and then terminating abruptly; next, a commencement at the low note, and gradually ending with the high one, also finished abruptly. Guns are not heard to their full intensity, because, as with the electric spark appreciated by the eye, a certain time is required to produce full excitation of the sentient nerves. Hence, at the Bellrock, R. Stevenson found horns a better fog-signal than guns.

XXIII. The first employment, as being the most certain to be trustworthy and useful, of telegraphic communication to light-houses, should be to give *time*-signals to outward-bound vessels. (See report to British Association, by Sir E. Belcher, R. N., in 1856.)

XXV. *b.* Consult Mr. Babbage on his excellent system, especially as the notation he employs is at once applicable, *mutatis mutandis*, to solving the preceding question, or XXV *a.*

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I. THE EVIDENCE OF M. FARADAY, ROYAL INSTITUTION, 21 ALBEMARLE STREET, W.

ROYAL INSTITUTION, *February* 25, 1860.

In 1836 I was appointed "Scientific adviser to the Corporation of the Trinity House in experiments on lights." Since then a large part of my attention has been given to light-houses in respect of their ventilation, their lightning conductors and arrangements, the impurity and cure of waters, the provision of domestic water, the examination of optical apparatus, &c., the results of which may be seen in various reports to the Trinity House. A very large part also of my consideration has been given to the numerous propositions of all kinds which have been and are presented continually to the corporation. Few of these present any reasonable prospect of practical and useful application, and I have been obliged to use my judgment chiefly in checking imperfect and unsafe propositions, rather than in forwarding any which could be advanced to a practical result. Hence, I cannot give simple answers to the queries beneath, and, therefore, think it better to refer, when there is occasion for it, to my carefully considered communications to the Trinity House. The Royal Commission may not think it necessary to refer to any, or, at all events, to many of these papers; but, as an illustration of my position and duty, I will refer, in the first instance, to a letter of inquiries, &c., of the date 8th February, 1860, relating to Prosser's lime light.

II. Not as yet.

Gurney oxyoil lamp.—Reports, 15th February, 1837; 15th January, 1838; 14th June, 1838; 29th October, 1838; 12th August, 1839. Great exertions were made to perfect this lamp, but its application failed.

Fitz-Maurice lime light.—21st July and 20th August, 1858.

Prosser's lime light.—Letter and inquiries, 8th February, 1860. (See the return to requisition, at the end.)

Watson's voltaic light.—Report, 15th August, 1854.

Way's mercurial electric lamp.—27th June, 1859.

Holmes's magneto-electric light.—His letter, 28th April, 1857; my comments, 1st May, 1857; my report, 29th April, 1859, and also 20th February, 1860.

Pyrotechnic mixtures, and the *association of steam with the lamp*, have been proposed; to the reports on which I do not refer.

IV. The best at present are the refracting and reflecting apparatus now in use.

V. The best at present are the arrangements now in use.

VII. *b. c. Moulded glass*, 16th January, 1860.

VIII. No.

IX. *b. Propositions as to reddening the light*, 12th July, 1837; 17th March, 1843; 26th December, 1845; 14th October, 1859.

X. *a.* Red from white.

b. White light is more serviceable and penetrating whilst white, than if reduced by the intervention of colored media.

XI. *a. b.* Approximations may be obtained occasionally, but they will be uncertain, because of the darkness, the unknown haziness of the atmosphere, and the refraction.

XIII. Such improvements in ventilation, or in other points, as have occurred to me have been already introduced.

XVI. *c. Messrs. Brown's ignited platinum wire*, 17th December, 1847.

XVIII, XIX, XX. *Parabolic reflector*, 16th August, 1848.

Whistle reflector, 24th March, 1853.

Whistle reflector, 22d September, 1853.

Electro-magnetic arrangement, 6th and 16th October, 1857.

Boulogne fog-bell and reflector, 24th October, 1859.

Start Point reflector, &c., 21st November, 1859.

XXI. Depends on the locality.

XXII. I think each locality requires special consideration.

CIRCULAR NO. II.

MARCH, 21, 1860.

I. I presume that in Great Britain, as abroad, there is always a competent authority, who considers and decides the circumstances of every particular light-house, and gives instructions to the competing manufacturers. I think a manufacturer should not, on his own judgment, interfere with the judgment of such an authority. He may know the height of the lantern above the sea, but ought not to vary his angles for any variation in that respect. The variation of the angles of the glass is rarely, if ever, the *kind of change* required. The authorities are conscious of the need of making the beam dip, *if necessary*, and always have the power of directing it. In respect of the horizontal arc, also, the authorities always, I believe, give the number of degrees, and the manufacturer should not use his judgment in the matter.

II. The manufacturer does not need this information to guide him in the grinding and fitting of his lenses, prisms, &c. He should receive a specification for an apparatus of well-known construction, to perform a certain well-known optical duty; and if, when it is examined, it does not perform that duty, it should be rejected.

III. There is not the slightest occasion for a table relating to the *horizontal arc*. The instruction is, in *any case*, for a certain number of *degrees*, with frames, bars, &c., in certain places, and the work simply has to be done. As to *elevation*, the depression of the ray necessary on that account is in the power of the authorities, being ordered especially, or governed by adjustment of the lamp, and it should not be interfered with by the manufacturer.

IV. I have no duty in this respect, but only that of examination; nevertheless, as far as I know by the results, the specification and instructions given by the authorities are sufficient for the purpose. Perfect numerical exactness in the angles cannot properly be directed or required; for the maker has, rightly, a power of improvement over his glass, and if his glass vary, the angle must vary also. The specification should tell everything that is necessary for the full information of the makers. The makers have their work subjected to a very close optical scrutiny; and it is probable that any attempt to refine further in their department might lead to the removal of responsibility from the parties who ought to bear it.

Return to requisition, dated 21st March, 1860, sent by desire of the Elder Brethren of the Trinity House, at the request of the Commissioners, after perusing Professor Faraday's evidence.

ROYAL INSTITUTION, *February* 8, 1860.

SIR: In reply to your letter of the 1st instant, I have drawn up a set of inquiries which, in my opinion, it would be necessary to make, and have answered, *before* any proposal to introduce the lime-light into a light-house could be considered. These I beg to summit to the consideration of the Deputy Master and Elder Brethren. As far as I am concerned, such preliminary inquiries and answers would be required in every like case.

I am, &c.,

M. FARADAY.

P. H. BERTHON, Esq., &c.

INQUIRIES, &C.

1. The Trinity House cannot undertake to consider a mere proposition, or an imperfect arrangement, but only such subjects as are presented to them in a practical state.

2. The Trinity House cannot undertake to work out or perfect the application of a proposition, though it may feel justified in undertaking to test a perfected arrangement, upon good reasons and data being submitted to it.

3. In order to enable the Trinity House to judge whether a proposition made to them by parties, not practically experienced in the service of light-houses, is well founded and has been thoroughly considered, it is desirable that certain questions should be answered, not from expectation only, but upon principle and from experience. These, in the present case, may be founded upon the requisities for a *first-order fixed light*, and may be as follows:

4. What is the quantity of light proposed to be supplied, expressed either in relation to a central Fresnel lamp of four wicks, or to an ordinary Argand burner, such as is used in a reflector?

5. The number of jets of gas required to ignite the lime?

6. The quantity of oxygen required for twelve hours?

7. The current price of the oxygen, *i. e.*, the cost of materials, wages, repairs, and any other current expense?

8. The manner of storing the oxygen?

9. The nature of the gas fuel; the quantity required in twelve hours?

10. How is the gas fuel to be obtained? How is it to be stored?

11. What is its current price for twelve hours, including material, wages, repairs, and other current expenses?

12. What is the shape and size of the lime or focal light? How often will it require renewal? How or where is it to be obtained? And what will be its current cost?

13. What degree of steadiness will the light possess? Is it *now* as steady as a well-burning lamp; or is it unsteady like a lamp in a draught; or does it sink and rise at intervals?

14. Will the attention of the keeper be of necessity perpetual? If not, for what intervals has the light been left, as yet, without falling off in character?

15. What is the vertical height and horizontal width of the *most* intense part of the luminous object; and what the height of the part which may be called generally intensely luminous?

16. What number of persons would it be necessary to employ *upon the spot* in relation to the light-houses, and what would be their occupations?

17. What buildings or outhouses for retorts, gasometers, &c., and what habitations, besides those now belonging to a first-order light-house, would be required?

18. Are the means of obtaining the light considered as applicable only in favorable situations, or in all ordinary situations? In the latter case, let the reply have relation to such a light-house as that at Dungeness or Flamborough Head.

19. Are there any exceptional cases where the light could not be applied with advantage, as the Needles, Eddystone, Bishops, Longships, Plymouth Breakwater, Casquets, Longstone, Bell Rock, Skerryvore, Stack, Smalls, Tuskar, and others? If so, are they supposed to be few or numerous?

20. Will the service of the lime light make it dependent upon the neighborhood of a town; or, if not so dependent, what kind of annual supplies, or supplies at considerable intervals, will probably be required?

21. What will be the probable *outfit* of the apparatus, with the buildings necessary for it, and for the accommodation of the extra staff required?

22. What will be the nature of the necessary repairs?

23. What will be the *whole current expense* of the application of the lime-light, including royalty, &c.?

The Trinity House cannot authorize any chance of interference with the *certainty of light-house action*, by the introduction of any uncertain or unproved arrangements tending to disturb the actual service of the light. It therefore requires full proof of the fitness of any proposed arrangement *before* considering its introduction into a light-house.

Any failure in such preliminary proof, or any serious departure in the *results* from the answers given to the questions 4, 5, 6, 7, 9, 10, 11, 12,

13, 14, 16, 17, 18, 20, 23, which can be as well obtained out of a light-house as in it, will be considered as showing that the proposed application has not been sufficiently matured, and if not removed by further investigation and proof, will lead to the conclusion that the method is not applicable to the service of light-houses.

M. FARADAY.

* * * * * * *

JUNE 24, 1860.

I. Sir J. F. W. Herschel, Bart., of Collingwood, Hawkhurst, Kent.

II. I am disposed to believe that, as a mode of producing an intense light, the simple combustion of oil (not previously reduced to gas by destructive distillation apart) is superseded by many forms of illumination practicable with ready access to those resources which can be commanded by money and science duly conjoined. Among others, the electric light, the lime light, (with the recently improved mode of keeping up a steady supply of the lime cylinder,) the combination of zinc, sulphur, or even phosphorus in oxygen, &c. The electric and the lime light appear to me, however, so far as my own knowledge and experience extend, the most practicable.

III. In remote and isolated positions, I should be disposed to adopt only such means of illumination as could be most securely relied on for continuous practical working, and in which difficult and delicate manipulations should not be required. Under almost any circumstances, I should think it well to be provided with the means of readily substituting an oil illumination for any recondite form of light which might be liable suddenly to get out of order. I am of opinion, that when the electric or lime light shall have become thoroughly reduced to practice, in easily accessible situations, their use may be gradually extended to more remote ones, but not at once.

IV. A recent discovery of Professor Liebig has supplied a mode of silvering (with a coating of perfectly pure silver, reflecting nearly 91 per cent. of the incident light*) glass surfaces of any figure or magnitude. A paraboloidal reflector of glass, worked by *Foucault's* process, if necessary, to a *perfectly* true paraboloidal form, and so silvered, would, I apprehend, be very likely to supersede the polyzonal lenses, &c., referred to as a means of throwing out the collected light of a central burner to a great distance. To give such a reflector its full effect, however, a very small and exceedingly intense central light would be almost indispensable, and for this purpose the electric *stellar* lights or the lime cylinder would be especially useful. Such a reflector must be made (or more than one) to revolve around the central light and sweep the horizon.

V. The object proposed being to illuminate with all the available light of the lamp the whole sea surface extending to the visible horizon from a certain moderate distance from the foot of the light tower, and that *continuously* and *simultaneously*. The first plan I have to propose is by the use of a reflector or reflectors of peculiar construction, as follows:

1st. *When not more than* 180° *of the circumference of the horizon requires to be illuminated.* From the known mean temperature of the station during the night hours, and from the barometric pressure, corresponding to the height above the sea of the light, calculate the mean amount of the dip of the *actually visible* sea horizon, (which is less than the *geometrical dip* by the mean amount of the *terrestrial* refraction due to that height and horizontal distance,) and let the angle so computed, diminished by the angle subtended at the light by the height of the deck of the largest ship placed on the verge of the visible horizon, be denoted by *d*. Since *mirage* or cases of extraordinary refraction are extremely unlikely to occur at night, this may be taken as the depression below the geometrical horizon of the highest ray which the reflecting apparatus ought to send forth. That of the lowest may be computed from the height of the light and the given distance from the light-tower foot to the nearer limit of the area requiring reflected illumination, considering the sea surface as a plane, and neglecting refraction.

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*By Steinheil's experiments. See, also, Jamin, *Ann. de Chem.*, xix, 305.

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VII. *a.* See reply to query 4. Liebig's process for silvering is given in the *Annalen des Chemie und Pharmacie*, xcviii, p. 132; Foucault's process of giving a parabolic figure in the "Notices of the Astronomical Society," vol. xix, p. 284.

VIII. Colored glass acts *by the destruction of a large percentage* of the total incident white light. It is, therefore, a *highly objectionable* thing *per se*, but I am not prepared to propound any naturally colored flame as capable of yielding a *very* intense light. It is very *possible* that, by substituting a cylinder of strontia for lime, or impregnating the lime with strontia, a very luminous red might be produced, but I have no experiments on a large scale to cite. Chloride of copper might give a green tinge, but would require constant renewal.

IX. *b.* The colors of most transparent media *deepen by heat*, and as the chimney is intensely heated, I should fear that a chimney of colored glass would destroy an unduly large percentage of light, and a variable one, depending on the temperature of the chimney at the moment.

X. *a.* In *all weathers* (meaning, of course, in hazy weather) the purest white is most likely to penetrate farthest, not by reason of its *color*, but its *imtensity*. Red is best distinguished as a color from white, but i[illegible] should rather be a luminous orange red, as transmitted through a not strongly colored brown glass, or the very luminous red, communicated by oxide of silver (? gold) to glasses, such as the more brilliant ancient church-window ROSE-red. Blue glasses colored with cob[illegible] transmit a very complex light, and are to be *especially avoided.* PA[illegible] red and PALE green give a good contrast, but there is a chance of col[illegible]-blind persons not perceiving it.

b. In fog, white by all means, *i. e.*, the *unintercepted total* light, [illegible] whatever color, the most intense the lamp can give. No sacrifice [illegible] light by any sort of obstruction or interception can be tolerated in f[illegible] A fog is sometimes red or yellow, but it would be absurd, *therefore*, [illegible] use a red or yellow *glass* to color the light in agreement with the f[illegible] These could only act by destroying the green and blue rays, which t[illegible] fog would do without their help.

XVIII, XIX. Every one has remarked the great distance to whic[illegible] steam railway whistle may be heard, but it would be worth trial w[illegible] would be the effect of a *battery* of *such* whistles, blown by high-press[illegible] steam, or by a combination of 3, or several sets of 3, pitched exactl[illegible] *harmonic* intervals, (key note, 3d, 5th, and octave,) but all of a very [illegible] pitch, and with a *rattle*, analogous to the pea in a common whistle, which intensifies the action on the auditory nerve, as a quick sparkling glitter does to the optic nerve, or as the interrupted shock of the medico-galvanic apparatus to the nerves of feeling.

XX. I know of none other than concave reflectors, large and of close textured material, or funnel-shaped apertures.

N. B. I have not a doubt that a *sub-aqueous* linear propagation of sound *to very great distances in given precise directions* might be accomplished by explosions or other sudden sounds in the focus of *large* and *heavy* parabolic reflectors. I set down this suggestion here to prevent its being patentized hereafter.

XXI. Above the probable level of the densest portions of the usual fogs of the locality, so as to give the greatest possible extent to the sound wave *in the clear air*, which might radiate thence downwards, by dispersion, into the fog from above.

XXII. This must entirely depend on the local peculiarities in respect of fog or haze. I have been informed that a light on the high chalk cliff, St. Catherine's Down, on the south coast of the Isle of Wight, was rendered useless by its too great elevation. In bad weather, when lights are most needed, clouds are low; actual *cloud*, I presume, however, seldom descends to 200 feet above the sea level, but rain is actually *more copious* at lower levels than at higher, and rain intercepts light as well as cloud.

XXIII. The most important meteorological communication which could be telegraphed would be information *just fresh received per telegraph* of a cyclone actually in progress at a great distance, and working its way *towards* the locality. There is no doubt that the progress of a cyclone *may* be so telegraphed, and *might* secure many a ship from danger by forewarning it. As to the *form*. I have no suggestion.

XXIV. Some localities may be well adapted to one system, some to another. The following seems to be universally applicable: Suppose the spring tides, for instance, to rise and fall six feet; to enlarge this to, say sixty, and render it and its single feet visible to a distant ship, attach a float to a ten-fall pulley, and let the cord, fixed at one end to the float, carry at the other loose end a bright lamp, which thus will rise and fall sixty feet; let it travel up and down a mast or other erection sixty feet high, and pass in succession six fixed lamps at ten feet distance from each other.

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XXV. *a*, *b*. On this point Mr. Babbage has some excellent ideas. If a copy of these queries have not been already sent him, it would be highly advisable to do so.

Circular No. II.

I. There seems to be no possible doubt as to the propriety of giving the manufacturer employed in constructing such an apparatus all possible information as to the circumstances under which it is intended to be used, and the precise nature and extent of the objects it is to accomplish. Where a definite arc in the horizon *only* is to be illuminated this information may lead to economy in the construction, or to peculiar adaptations of a special nature suiting the locality.

II. Most assuredly. If the information in question is of any importance at all, it ought to enter into and form a part of the working plan of the maker of the apparatus, so that he shall not have to alter his patterns, fittings, or any other part of his work.

III. IV. Unable to give any satisfactory reply.

Memorandum.—While these replies are passing through the press, I observe that Mr. T. Stevenson's valuable work "On Light-house Illumination on the Holophotal System," which I had not seen when the construction in my replies to query V were devised, (my knowledge of his hemispherical appendage being derived from another quarter,) that a construction identical in its general principle with the first of those has been already proposed by M. Bordier Marcet and executed by Mr. A. Gordon. In Marcet's construction, however, the generating curve is a parabola, having its axis horizontal, by which arrangement the light, instead of being dispersed over the visible sea surface, is thrown out in a parallel horizontal sheet into the air beyond the offing, and only irregularly reflected rays, or those emanating from the unfocused portions of the lamp flame, can reach the surface.

J. F. W. H.

I. Colonel J. T. Smith, late of the Madras Engineers.

II. III. I know of no improvements.

V. In a separate memorandum (A) I have mentioned two modifications of the existing arrangements, one of which has been tried with success, the other was proposed by me many years ago.

(A.)

Under special circumstances, I adopted a "*reciprocating*" light for Madras, which has now been in use 16 years, and answers the purpose exceedingly well, being more economical than an ordinary revolving light, in the ratio of three to five. The same principle has been applied elsewhere, but it is not advisable in any case where it is, or may hereafter be, important to measure the exact periods of light and darkness.

I have long been of opinion that an improvement may be made in the method of utilizing light by refraction. The change I propose being that of using crossed prisms instead of lenses for revolving lights, somewhat like what has already been done by M. Fresnel, but differing in this, that instead of the prisms being of very nearly the same focal distance, they should be materially and essentially different; that which collects the rays horizontally being much shorter, with the view of increasing the horizontal divergence of the beam and consequent length of the flash. On this subject a paper was submitted by me to the Honourable Trinity Board 23 years ago, viz., on the 11th August, 1837, and I should be very glad, if any solid objection has been urged against the views therein stated, to be made acquainted with it. It appears to me that any plan which bids fair to add length to the flash of the French lens (at present only 4° or 5°) is deserving of experimental trial.

V. Theoretically, and in the abstract, nothing can be superior to Fresnel's catadioptric system; but, nevertheless, in certain cases the catoptric method is preferable; and a slight modification of this, which I have detailed in memorandum (B) is, I think, worthy of experiment.

(B.)

In remote inaccessible localities, where the apparatus for fixed lights is required to be simple, more especially if only a part of the horizon is to be illuminated, the catoptric is superior to the dioptric system, and any improvement of the former may be of value. I would suggest the trial of a different form of lamp from that commonly used with the parabolic reflector. Instead of having a circular wick of one inch diameter, I propose to try an oval shape, or rather rectangular, with circular ends, thus placed with its longest diameter in line with the axis. This would much increase the power of the reflector, and, I calculate, when several are used to fill adjoining parts of the horizon, each would fill 22° with an uniform amount of light, equalling 350 Argand flames. If this be correct, 18 reflectors would amply fill 360° of the horizon, and a smaller number in proportion any part of it, while, to produce an *equal* effect with the common Trinity House mirror of three inches focus, I calculate 45 would be necessary. The consumption of oil, however, by the new lamps, would be greater than the present, in the proportion of seven to three, so that there would be little or no economy of oil. The improvement to be looked for (the plan has not been tried) would be the more perfect uniformity of the belt of rays produced by a series of reflectors, and the convenience of accomplishing the object with a much smaller number of them.

I ought not to omit to mention the system of fixed lights adopted by me in 1839, and which has been in use ever since, and is now established in fifteen to twenty different localities in India, where it has given great satisfaction. It consists of a series of reflectors of a peculiar shape, which I have called "periscopic," and they possess the advantage of giving *perfectly* uniform light throughout 180° of the horizon, of any required degree of *power*, varying from about 30 Argand flames (the effect of one lamp and reflector) to 360 or more, according to the number used. They have hitherto been generally applied three or four together, and it has been found that four to six combined give an excellent light for 16 or 18 miles distance. Twenty-four "periscopic" reflectors, 3 feet high, 1½ feet broad, would fill the whole circumference with the uniform light of 360 Argand flames, consuming no more oil than 24 common Argand lamps, but they are not suited for the Argand lamp, having a lamp of their own, of peculiarly simple construction, which is a great advantage where trained light keepers cannot be had.

This system is referred to by Mr. Alan Stevenson in his Rudimentary Treatise on Light-houses, Part I, p. 121, though in terms of disparagement. It is true the instruments are theoretically inferior in respect to the collection and utilization of the rays, even to the common parabolic mirror, but they have, nevertheless, been found practically of the greatest use in situations where more perfect and complicated apparatus would be worthless, and I am of opinion that the principle of the system is deserving of attention and some little trouble taken for its improvement. It is apt to be hastily condemned, because *one* periscopic reflector, in any given azimuth, is only one-twelfth as powerful as a comm parabolic reflector, it being overlooked that it is at the same time do the work, in part, of 11 other reflectors, so that when 12 of each compared together the "periscopic" may have the advantage.

VII, X. I have no suggestion to make.

XI, XVI. I have no new method to propose.

XVII, XXV. I have no suggestions to offer on this subject.

CIRCULAR NO. II.

I. If by "manufacturer," we are to understand the person who is to design the arrangement and specify the apparatus to be used, I should think it would be not only advantageous but necessary that he should have the information referred to, especially *b*; but the purpose for which the information is required falls within the province of the lighthouse engineer, rather than that of the manufacturer.

II. The whole arrangement of the apparatus, and exact position of every part, ought certainly to be settled before any new work of a special character is begun, and for that purpose the information is required, as above stated. But all the various instruments now used, such as polyzonal lenses, cylindric refractors, catadioptric zones, holophotal lenses and reflectors, parabolic and other mirrors, with their lamps, ar themselves, I believe, made according to fixed patterns; and if the are to be used entire, it would be immaterial in what way they ar afterwards arranged, except in rare cases.

III. I think, perhaps, I do not quite comprehend the meaning of th question. I am not aware that it is usual to alter the details of t *instruments* to suit the height from which they are to be exhibited. ordinary cases, the vertical divergence of the rays is sufficient to m the requirements; if not, an angle of depression may be given to t axis of the beam of rays from a reflector or refractor, by "canting" forwards, or replacing the lamp a little above the true focus; and latter method may be applied to a cylindric refractor.

In regard to the horizontal arc to be filled, there are so many differ points to be considered in each case, and so many different kinds instruments, all of different special qualities and uses, from which most appropriate selection is to be made, that I do not think the c could be met by any table. Perhaps an instance may make this cle I have just been asked to design a light, of which the requirements as follows: It is to be in a remote and very inaccessible locality, inh ited by *extremely* ignorant people. Height 350 feet, arc to be illumi ted about 200°; but the middle part of this arc, say 130°, only requi a comparative feeble illumination, the two edges, say of 20° each, mu be lighted with the full strength, visible 25 miles. Great simplicity the working parts desirable. All these considerations could not expressed by numbers, or tabulated. I think it probable that fo "periscopic" and four common parabolic, or, perhaps, even, holophot mirrors, may suit the objects required.

The design and arrangement of the apparatus to be used, and th mode of using it, must be made by a person thoroughly conversa with the subject, and well acquainted with every kind of instrumen and the precise capabilities and virtues of each; and to such a perso it appears to me, no table would be of much use.

IV. I have never met or heard of any such a table as that proposed.

I. Richard Potter, A. M., formerly Fellow of Queen's College, Cambridge, Professor of Natural Philosophy and Astronomy in University College, London.

II. I am not aware of any light which I think in all respects preferable to an oil or gas lamp of the best construction. I know well the lime light and electric light, they give *very bright* light from *small* shining surfaces, and in some optical experiments this is a great advantage, but in light-houses *a much larger quantity* of light must be needed, although it may arise from flames with very much greater shining surfaces.

III. From the answer to question II, it must arise that, I think, independently of the labor and attention which the lime light and electric light require, the most improved forms of oil and gas lights should be mployed.

IV. My experiments in photometry, made many years ago, were the ost extensive and various that have ever been undertaken. My expeience and my actual determination of the loss of light in passing hrough a thickness of two inches of clear flint glass have long led me doubt the great advantages which have been claimed for the polynal lenses of M. Fresnel. I found about *one-fourth* of the light to be st by reflection and absorption, in passing through a thickness of *two ches* of such glass with highly polished surfaces. I found, in like manr, that a good ordinary looking-glass reflects *sixteenths* to *two-thirds* of e light falling upon it, and that highly polished mirrors of speculum etal, as used in the reflecting telescope, reflect still more, according ith Sir William Hershel's results. I accordingly see that little, if any, vantage is gained in the quantity of transmitted light of a polyzol lens over the quantity of reflected light from mirrors of ordinary oking-glass of the same apertures; and if mirrors of proper form and e could be obtained of the new silvered glass, I think the quantity light from a given lamp would be much in favor of the mirror. her objections against the polyzonal lens are, the loss of light by struction of the opaque mounting of the segments, and the impossility of thus building up the lens with true optical accuracy. Nevereless, where the light is required to be continuous *in all directions* ound a light-house of low elevation, and therefore the offing is not ry distant, the *refracting* method of concentrating the light might be e best, since the mirror obstructs the light in one direction, whilst ses may be placed all around it. In the latter circumstances, *semi-indrical rings* of glass around the flame might be tried to concentrate light upon all points of the offing at the same time. If an illumition upon or within the horizon may be at *recurring* intervals, then, m what has been said, it will be seen that, I think, the best mirrors best oil and gas lamps. will be the most serviceable apparatus; embering, also, that mirrors can be made of much larger proportional rtures than lenses.

I think for *continuous* illumination, and in *all directions* around the t at the *same time*, that *semi-cylindrical* rings of glass around the t will be the most effective.

I. I think the semi-cylindrical ring of glass the best concentrator the light of a floating light, because the offing will never be very tant, and a continuous bright light in all directions is very desirable.

VII. *a.* I think, as before stated, that the new chemically silve glass mirrors should be carefully tried for mirrors of light-houses. expect there would be no difficulty in getting the plate-glass form and polished to a true parabolic figure before the silvering took plac

c. The manufacture of the *semi-cylindrical* rings before named wou I think, offer no difficulty.

d. I think, where a parabolic mirror is used, the light from the fr of the lamp not falling upon the mirror might be employed by mea of mirrors, prisms, or semi-cylinders of glass, to illuminate the obje on or near the surface of the sea near to the light-house.

VIII. I think glass prisms of considerable size may be used to p duce colored beams of light with advantage in *some* cases, but in oth colored glasses must be resorted to at a greater or less distance fr the flame of the light, to be determined by experiments.

IX. *a.* The light of oil and gas flames is a *full orange light*, as is eas shown by comparing it by photometry with daylight, and it conta only a small proportion of blue light, so that dark blue glasses transmit but little light from such flames, and are therefore very obj tionable.

b. If sufficient changes can be produced by green and red glass they should be employed only, and not too dark, but changing from to the other quickly, as the eye is impressed by contrasts, but so accommodates itself to one species of illumination.

X. *a.* It will be seen in the answer to the last question the nature oil and gas flames restricts the colored glasses to shades ranging throu red, orange, yellow, and green.

b. I consider that white light is unattainable for light-houses. think the *large quantity* of light from large flames the best in hazy foggy weather.

XI. *a.* I think the succession of colors from the beam given by a la prism might be employed to indicate *the distance* from the light wh sailing near to it, or a series of colored glasses might be used, the ves coming into green light being in danger, and into red light being excessive danger.

b. The mechanical arrangements to be ascertained after the succ of the previous step is known.

XVI. *c.* I think buoys may have *strong hermetically sealed* spheri *silvered* glass bottles attached to them, which could be illuminated fr a distant shore, so as to be seen from vessels *near them* in any directi

XVIII. A steam trumpet or horn is used in the neighborhood Hampstead Road, and when it roars it would awaken the sleepiest s ject, and it is heard to great distances when bells are not heard.

XX. They might be directed to try the ear-trumpet, to determine direction of sound.

XXII. In certain situations, both high and low lights should be us When low lights were not used, powerful reflectors, near the sho receiving light from the high light, might be used.

I. G. A. Miller, Lamp Maker to the Admiralty, 179 Piccadilly.

II. I am not aware of any better method than burning oil.

V. Our experience extends to the manufacture of lamps with lens of various sizes up to eight inches in diameter. *Plano-convex* lenses a seen at the greatest distance, if accurately formed, and the lamps well made. A modification of this form into curves is necessary for *spreading* light, but which it is obvious is proportionately weakened in the distance.

VII. *a.* The best and most convenient material for reflectors, is well-plated copper, and the parabolic form, reflecting the light parallel to the axis, is best calculated for lights to be seen at the greatest distance.

b. c. d. Messrs. Chance & Co., Birmingham, would afford this information.

VIII. No.

IX. *a.* Messrs. Chance & Co., Birmingham.

b. Colored lenses being now very brilliant by means of *coating*, are preferable to loose glasses, where they can be used as being more simple and safer.

X. *a.* Bright ruby. The tint to be in relation to the power of the flame.

b. Bright ruby would, I think, be best distinguished.

XII, XIII. We have no experience in the manufacture of light-houses.

I. Robert Mallet, Mem. Ins. C.E., F.R.S., 11 Bridge street, Westminster, and 97 Capel street, Dublin.

II. In light-houses easy of access, I am in possession of plans for illuminating by good coal gas, which I wish to lay before the Commission. The mode of illumination is catadioptric. The gas is burnt by a method much superior to any hitherto suggested, and the discoverable causes of accidental extinction are nullified. In cheapness, nothing approaches gas.

III. I do not, in the case of floating or remote and perfectly insulated lights. It is applicable to all shore lights.

IV. I am not prepared to answer this briefly.

V. Totally reflecting prisms, or those in combination with polyzonal lenses.

VI. With sufficient size of light-ship to admit of making good coal gas on board, I see no difficulty in adapting my method to a floating light.

VII. *d.* A part of my arrangements have this in view.

VIII. When the action of magneto-electric light shall have been practically perfected, it is not difficult to see that means will be developed for producing at will changes of color incomparably superior to any device hitherto proposed.

X. *b. Practically,* I believe white light the best.

XII. I am prepared to suggest methods of construction in malleable iron (plate iron principally) calculated to produce great reduction in cost, rapidity of execution, and without loss either of stability or durability. The same applies to beacons.

XV. *a.* I believe the ease of riding may be materially improved, as also the safety, by a better point of application of the cable to the ship, and by elastic connection.

XVI. *c.* When the magneto-electric illumination shall have become perfected this will be easily accomplished.

XVIII, XIX, XX. To the subject of fog-signals I have devoted a good deal of attention, and am desirous of laying before the Commission designs for acoustic signals, which I deem to embrace important improvements. *Explosive* sounds are those that will penetrate farthest. Of *continuous* sounds, those of high pitch are heard best. Explosive sounds give the best indication of direction.

XX *bis*. My improvements particularly refer to these.

XXI. Depends upon the average height of sea fogs above the water at the place. This being known, a principle to fix the height may be shown.

XXII. Answer to XXI embraces a good deal of this.

XXIII. Wind in shore, and movement of the barometer at the site, I should suppose, but am not specially informed on this head.

CIRCULAR NO. II.

I. I think both should be officially given in all cases. The information under letter *b*, so far as my information extends, is *always* given at present.

II. If given at all, they should clearly be given in the first instance.

III. It would; but in the hands of the manufacturer I doubt its utility.

IV. I believe not. The *methods* of the manufacturers I have reason to think are not conducted with rigid regard to scientific rule.

I. Robert Fitzroy, Rear Admiral.

II. I do not think that any method is preferable to the *best* arrangement for burning *vegetable* oil with oxygen gas.

III. No method is so generally reliable, under all varieties of circumstances, as that of burning good oil.

IV. Large polyzonal lenses, or sections of a circular lens.

V. The answer to No. IV refers to *revolving* light; this question, (V,) having reference to *fixed* light, is separated in character. My reply is, combined dioptric and catadioptric sections of lenses and prisms.

VI. By no means. A floating light should have a combination of parabolic reflectors and Argand lamps, so fitted as to preserve the reflector vertical in any motion of the ship.

VII. *a*. Reflectors should be, in their horizontal section, hyperbolas; but in vertical section, parabolas, where light is to be spread horizontally. The purest copper, well silvered and highly polished, should be used.

b. Glass should be the very purest flint, without lead or other mixture that may injure its transparency when heated.

c. Lenses and prisms should be as perfect as art and money can obtain, since the least deviation from exact mathematical accuracy in the prism near the centre or focus of light, magnifies, in proportion to the distance, error of direction in the refracted or reflected ray.

d. Optical apparatus should be so placed as to throw the light to the visible horizon, and thence to within a cable's length of the lantern; *not* horizontally, if the light be much elevated.

VIII. Colored glass is the surest under all circumstances; but color is suitable only for limited distances and minor uses, such as those of harbors and narrow waters.

IX. *a.* Colored glass should be very pure and free from lead, or it will soon become opaque after being continuously heated.

b. Colored glass, so placed *without* the lens as to be accessible for *cleaning*, and as thin as may be consistent with sufficient strength, is better than colored chimneys, (which intercept too much light, and become less transparent, if not opaque, by heat,) or colored panes, or screens *within* the lens, (which are not so accessible for cleaning.) The panes of a lantern are too thick to bear being well *colored* without an approach to *obscurity*.

X. *a.* Red, blue, and green, in this order of visibility; but neither can be seen at a long distance.

b. White light, as by far the most powerful; but no light can be seen far, if at all, in a fog.

XI. Yes, more than one.

a. Vertical angles of the lantern with the base of the tower, or the water line below it, and the distance run by time and log, will give the distance of the light trigonometrically.

b. Assume a height and compute distance as above. Run a second short distance by log, and take vertical angle; compute the same angle. If too large, try a less height; if too small an angle, try a greater assumed height, till the observed and computed angles agree. This may be done by inspection with any ordinary masthead table, quite near enough for common practical purposes.

For such merely *approximate* measurements a sextant answers, (on and off the arc,) but a Rochon or other surveying micrometer is better. The light tower itself, or its summit above the water line, serving as a base for rough calculation.

XII. *a. b.* This question is too extensive, and varies too much with localities, to be here answered specifically. Each place may differ more or less from others.

XIII. My acquaintance with many late improvements does not enable me to reply.

XIV. Such a form as will give sufficient stability and easy motion with the least resistance to currents and winds.

A form, moreover, that will enable a constant supervision of the moorings to be vigilantly kept, and a comparatively easy substitution of chains or ground tackle.

XV. *a. b.* Answers to these questions would vary with the localities implied.

XVI. *a. b.* Similar replies.

c. For *temporary* purposes *only*, small strong lanterns may be attached. In some few places a flexible gas pipe might be attached to a buoy.

XVII. No. Buoyage is dependent, essentially, on local circumstances, and cannot be *generalized* without incurring risks infinitely disproportionate to the (theoretical?) advantages.

XVIII. A sharp or high *pitch*, such as that of a screech or whistle, or a fog-horn. I think the fog-horn, if well made and worked by lever pressure, is the most powerful *high* sound.

XIX. Guns and large gongs or bells.

XX. Trumpet-mouthed devices. Such contrivances send sound in concentrated lines, showing whence it comes.

XXI. As low as possible. Sound travels along water farther than through unconfined air. It usually rises as it diverges.

XXII. The elevation ought to depend partly on the object of the light and its power. If for a "land-fall light" of the "first order," it may be a few hundred feet above the sea, (not more than 500, however,) but if for a warning or leading light, the lower it is the better, if not below 50 feet, (to clear the spray.)

XXIII. Height of barometer, wind and weather expected, received from coast guard, by telegraph, from other places, or from their own means and knowledge.

XXIV. Balls and cones by day; colored lights by night.

XXV. *a.* By colors, stripes, bars, ball, or triangle devices in white, black, or red, and by special marks (such as a pillar) near the tower or building. Floating lights should have framed balls or cones at their mastheads, painted red or black.

b. Yes; in some places a tall tower showing a high and a low light, one at least 50 feet above the other, vertically, would be a desirable variety. No system of letters lighted at night can serve, because all such small lights near each other either blend or do not show with distinctness at a comparatively short distance.

* * * * * * * * * *

I. William John Macquorn Rankine, Civil Engineer, LL. D., Professor of Civil Engineering and Mechanics in the University of Glasgow.

II. Not that I know of my own observation.

IV. Polyzonal lenses and totally reflecting prisms, in a frame surrounding one central lamp. When it is required to concentrate the light into one beam, a "holophotal" glass reflector to be combined with a polyzonal lens and totally reflecting prisms.—(See "Thomas Stevenson on Light-house Illumination.")

V. To illuminate the whole horizon, ring-shaped lenses and totally reflecting prisms of figures described about a vertical axis. To illuminate an arc of the horizon, these to be suitably combined with holophotal reflectors and prisms.

X. *a.* Red.

b. White.

XI. To determine the distance of a light while sailing directly towards it, on the supposition that the effect of atmospheric refraction is inappreciable.

a. The height of the ship's deck above the water being also known, let the difference of those two heights, that is, the height of the light above the level of the ship's deck, be denoted by H.

By means of an instrument capable of measuring angles of altitude at night, (such as that invented by Professor Piazzi Smyth, Astronomer Royal for Scotland,) take the altitude of the light. Let this angle be denoted by A.

Let R denote the earth's radius, that is, on an average, about 20,887,500 feet, or 3,438 nautical miles.

Let x be the distance from the ship to the light, then, very nearly,

$$x = \sqrt{2RH + R^2 \tan^2 A} - R \tan A.$$

If R and H are both expressed in feet, x will be computed in feet also, which may be reduced to nautical miles. If it is preferred to compute the distance in nautical miles at once, the height H should be reduced to a fraction of a nautical mile, and the radius of the earth R also expressed in nautical miles.

b. Take a first altitude of the light, and let it be denoted by A′.

After the vessel has run a known distance, as measured by the log, directly towards the light, take a second altitude of the light A″.

Let D be the distance run in the interval between taking the two altitudes.

Let R denote, as before, the radius of the earth.

Let x be the distance of the ship from the light at the instant of taking the *second* altitude—then,

$$x = \left\{ \frac{D^2}{2R} + D \tan A' \right\} \div \left(\tan A'' - \tan A' - \frac{D}{R} \right)$$

EFFECT OF REFRACTION.

According to the mode of allowing for terrestrial refraction commonly practised in geodesy, $(1+c)$ R would be substituted for R in each of the preceding formulæ, c being a fraction whose value fluctuates between $\frac{1}{7}$ and $\frac{1}{18}$, according to the state of the atmosphere.

The practical utility of both processes for finding the distance of a light from a ship, and especially of the first, is rendered very doubtful by the great uncertainty and variability of the refraction of light by the atmosphere near the surface of the sea. The degree of precision of which they are capable might easily be ascertained by experiment.

XIV. Circular. To be moored by the centre of gravity.

XV. *a.* The lines of direction of the cables as they leave the hawse-holes should pass as near as possible to the centre of gravity of the vessel.

XVI. *a.* Tall cylinders, ballasted so as to float upright; their diameters not to be greater than is necessary to make them sufficiently visible.

XVIII. A large deep-toned bell.

XX. Parabolic reflectors, to concentrate sound.

Parabolic ear-trumpet, to find the direction approximately.

XXII. This question might be answered by collecting the results of observations as to the visibility of existing lights.

* * * * * * * * * *

I. William Henwood, Master Shipwright, Sheerness Yard.

XIV. The best form for the hull of a floating light would, I consider, be similar to that for a sea-going vessel which is very fast with the wind aft. It should have the least possible direct resistance, to render the strain on the moorings a minimum, and the least possible rolling and pitching motion, that the light may be steady.

The size of the vessel being given, the proportions of length and breadth should be those of a fast vessel, as above stated, with a flat floor and fine entrance, and the after end to balance the fore, so as to make the longitudinal stability of the fore end not less than that of the after, or about five per cent. greater, to make pitching a minimum.

The suggestion of a "circular form" is indefinite. A cylinder may be regarded as a circular form, but its axis may be either vertical or horizontal, &c.; but such a form would produce great strain on the moorings, and a great motion of the light.

The form for great velocity, with the wind aft, would give stability to sustain the mooring strain, with the least pitching and least strain on the moorings.

If an iron vessel be intended, the mooring chain would not be injured by the galvanic action of copper sheathing and sea water, as in a wood vessel.

The upper works should be low, with little overhang of bow and quarters.

XV. *a.* I venture to suggest, that if a floating light were moored by a single chain through a hawse hole at the middle line of the stem, and as little above the water as may be, and secured at the middle line of the vessel, low down on the inside, she would ride most easily in all weathers.

* * * * * * *

I. George William Lenox, F. R. G. S., Assoc. I. N. A., 30 Bedford Square, W. C.

V, VI, and VII. If not already obtained, I recommend the opinion of Alexander Gordon, Esq., C. E., &c., 3 Middle Scotland Yard, to be taken.

XIII. Refer to Mr. Gordon.

XIV. I consider the best form would be a long flat floor or midship section. A sharp entrance and easy flare upwards, a stern delivery of same shape, of same length, both ends nearly alike, with the exception of the upper works, the deck of which might be spread and rounded astern.

My reasons are, a long flat floor would make the pitch to the sea easier and longer, offering less jerk to the moorings. The bow would take the blow of the sea in less body, and the bound upwards and consequent violence upon the cables more moderate. The stern upon falling would enter the water easier, and consequently the motion would subside sooner. A round bow and stern keeps up a continual tossing until the swell subsides. The flat floor would be the pivot, and the ends the mere means of breaking the water; thus the moorings would be relieved of much strain and violence.

I decidedly think a circular form would prove objectionable, and occasionally give a rotary motion.

XV. *a.* I cannot, believing from great experience that no method can be more secure than that at present adopted by the honorable the Corporation of the Trinity House, and my opinion is supported by the fact that there are now 34 light-vessels moored in every dangerous part of our coast, and, notwithstanding the severity of the last winter, not one rupture has taken place since January, 1857, when a chain, supplied in 1851 to the Helwick light-vessel, parted, and that the only one, to the best of my recollection, in from seven to eight years.

A Belgian light-vessel, on the Daerdemarkt bank, moored 12 years uninterruptedly at the same mooring, wore them through and parted during the late gales, and the government have ordered a new set of moorings on the same system.

b. In my opinion, the best point of entrance for the mooring is that, when circumstances will admit, which is nearest to the line of flotation, at the fore-foot, because the line of tension is more direct to the fixed point or anchor, and there is less leverage offered by the bow of the vessel, over which the chain must pass.

XVI. *a.* Beyond all comparison, in my opinion, what is called the Herbert or inverted cone bottom is the best. Its motion is most gentle and easy, as if riding on an elastic cushion. Its principle may be thus described: Take a tumbler and fill it with water: take a wine glass turned over, place it in the water on its side, that the air may escape from within, hold it erect in the water, depress and lift it, and you will observe a column of water will remain in the wine glass when drawn up, the tendency of which is gently to draw the wine glass again to the tumbler, thus forming an adhesive spring, upon which the buoy rebounds in gentle and easy motion, giving but moderate friction to the mooring chain, little or no pull upon the sinker, and a corresponding relief from agitation or friction to the globe and staff above. They are more expensive than plain-made can or beacon buoys: and cost, with the *Board of Trade* and others, has been the ghost by which the present generation has been scared from consistency, and which has led to cheap and infamous productions, and lately to such frightful loss of life. If expense had not been considered, these buoys would have been universal, and the cheapest by far in the end. They set with least strain upon the moorings, are quite upright when uninjured or free from leakage, and are consequently seen, when built of a bold form, at the greatest distance. The method of mooring, in my opinion, is excellent.

b. The buoy I should here recommend, where not so much wear exists, is my flat-bottomed wrought-iron can buoy, with the mooring ring housed in the centre of the bottom. It is an erect, strong, and perfect buoy, and at less cost than the cone-bottomed buoy, to which I consider it next best, and in sheltered situations as good.

c. None, in my opinion, practicable within the reach of our present knowledge of chemistry.

XVII. This, to me, is a most essential and interesting point, and I have given it much attention. I addressed a letter upon the subject to the Secretary of the Trinity House, dated the 25th December, 1855, and received a reply, dated the 17th January, 1856, declining to entertain the project then, since which I have considered the plan could be generalized.

First. I propose all buoys in the British Channel to be painted on the port bow or entrance black, and all on the larboard bow to be chequered in black and white, the whole to be cone-bottomed or Herbert's buoys: the first six or out-sea, on either side of the channel, to be 11-foot buoys, whose base would carry the proposed signals in any weather: the next line to be 9-foot, and the inner or home to be 6-foot buoys.

The first, on either side, to carry a 3-foot globe on upper end of a vertical staff. The second, on either side, to carry an upper 3-foot globe, and at one foot below, a 2-foot globe. The third, on either side, a 3-foot globe, and two 2-feet globes under, each one foot apart. The fourth, on either side, a horizontal staff, with a 3-feet globe in centre. The fifth pair of buoys two 3-feet globes, one foot apart. The sixth pair of buoys, a centre 3-feet globe, and one of 2 feet on each side, as shown, and if it is desirable to increase the number of distinct signal buoys I would add one more set with four globes at each end of vertical and horizontal staffs. The smaller or home buoys to carry a 3 or 2-feet globe only as now. Thus, taking the buoys alternately at five miles apart, there would be 70 miles of channel significantly buoyed.

In the St. George's Channel I would recommend the same system. The buoys to be painted red on the port bow, and chequered red and white on the larboard, and the signals to be square cages instead of globes; the design to be the same.

And, lastly, in the Bristol Channel, the port buoys to be painted a good stone color, (or what is called "in ordinary,") or like Messrs. Blyth's ships, the larboard to be alternate black and stone rings horizontally, and the signals to be lozenges, or diamonds, or triangles.

In addition to this organized system, I would recommend a good bell-buoy to be placed on all dangerous rocks and sands, and at the entrance of any harbor or place of refuge to be entered at night. I enclose a lithograph of my bell-buoys.

XIX. The bell, as worked by a good bell-buoy, without shield or housing, beyond a mere cap to keep rain or snow off, letting it verberate on the atmosphere. I would recommend all stationary beacons on land, sands, or rocks to be furnished with a bell to be rung by a weight, which might be wound up once in twenty-four hours. I have a model.

[From "Cosmos," March 2 and 16, 1860.]

VARIÉTÉS.

Optique, acoustique, et mécanique des Phares.

I. L'Abbé Moigno.

La commission royale des Phares d'Angleterre, composée de MM. Baillie Hamilton, (rear admiral,) Ryder, (capitaine de vaisseau,) Hall, Gladstone, Duncan Dunbar, (président du Bureau de Marine de Londres,) Graves, (président du Bureau de Marine de Liverpool,) nous adresse une série de questions, sur lesquelles elle voudrait avoir l'avis motivé des savants les plus compétents; nous empressons de répondre à l'appel qui nous est fait, en publiant, son programme dans le *Cosmos*, et lui donnant dès aujourd'hui quelques indications utiles.

OPTIQUE—*Production de la lumière.*—1°. Pour les phares et les fanaux flottants d'un facile accès, pensez-vous qu'il existe un procédé de production de la lumière, de nature à donner de meilleurs résultats que la combustion de l'huile? Si ce moyen existe, daignez le décrire en quelques mots. On emploie le gaz dans quelques feux de ports; la lumière électrique, engendrée par les machines magnéto-électriques, est en expérience depuis quelque temps à Douvre, dans le phare South-Foreland; d'autres moyens semblables, l'emploi, par exemple, de la lumière Drummond, ont été proposés. Nous engageons vivement la commission à se procurer et à étudier sérieusement l'opuscule de M. Jules Guyot sur

la télégraphie de jour et de nuit, (Paris, 1840.) Elle y verra, par exemple, que pour les petits feux, et peut-être même pour les grands feux, l'hydrogène liquide remplacera avec d'immenses avantages le gaz et les huiles. Mais que la commission le remarue bien, l'hydrogène liquide de M. Jules Guyot diffère essentiellement des produits adultérés, vendus sous ce nom dans le commerce, et qui ne sont que de simples mélanges d'alcohol, d'essence de térébinthine ou d'huile de schiste. Si elle s'adresse à M. Degrand, administrateur général du service des phares français, la commission obtiendra des chiffres parfaitement exacts et très-concluants sur l'emploi économique de la lumière électrique, engendrée par les machines de la compagnie *l'Alliance*, lesquelles, avec une force de deux chevaux donnent directement une lumiere equivalente à celle de 200 lampes, et les nouvelles lentilles fondues de M. Degrand donnent directement une lumière equivalente à plus de cinq mille lampes en ciel Carcel. 2°. Prenant en considération les difficultés de transport aux phares et aux feux flottants, installés dans des positions isolées, lointaines, très-difficilement accessibles, et le danger qui résulte de l'extinction de ces feux, pensez-vous que le mode de production de lumière que vous proposez puisse être substitué sans inconvénients graves à l'éclairage à l'huile ? L'hydrogène liquide, obtenu par la combinaison de trois substances abondamment répandues dans le commerce, peut être préparé sur place, ou peut se transporter sans embarras aucun ; la lumière qu'il donne est presque inextinguible. (*Voyez la brochure*, p. 143.) Les machines magnéto-électriques n'exigeant plus qu'un simple transport de charbon, l'approvisionnement ne manquera jamais.

Utilisation de la lumière.—1°. Quel arrangement optique considérez-vous comme le meilleur ou le plus efficace pour envoyer à l'horizon, ou sur un point situé en deçà de l'horizon, pendant de courtes périodes, se succédant par intervalles réguliers ou irréguliers, la plus grande proportion possible de la lumière résultant de la combustion d'une quantité donnée d'huile, ou produite par une autre méthode quelconque ? On a employé ou proposé déjà les réflecteurs métalliques et autres, les lentilles polygonales, mécaniquement polies ou fondues, les prismes à réflection totale, simples ou combinés, etc. Cette partie du programme a été si complétement étudiée par M. Degrand, ses lentilles à échelons fondues et très-minces ont donné de si étonnants résultats que nous ne croyons pas qu'on puisse rien y ajouter d'essentiel. 2°. Quelle disposition optique considérez-vous comme la meilleure pour envoyer d'une manière continue et simultanément aux divers points situés à l'horizon ou en deçà de l'horizon la plus grande quantité possible de la lumière engendrée ? Même réponse, renvoi à M. Degrand. 3°. Considérez-vous les méthodes que vous avez décrites, comme applicables aux feux flottants, avec ou sans modifications ; si des modifications sont nécessaires, veuillez les indiquer ici en quelques mots, ou les décrire longuement sur une feuille séparée ? L'hydrogène liquide s'emploie absolument comme l'huile, et beaucoup plus facilement que le gaz. 4°. Pouvez-vous nous communiquer les réflexions que vous avez pu faire sur la fabrication des réflecteurs, en y comprenant la matière et la forme, la fabrication du verre, la construction des lentilles et des prismes, l'installation des appareils optiques dans les phares de manière à obtenir les plus grands avantages possibles, en ce qui regarde la position et l'élévation de la lumière. Faire appel sur tous ces points à M. Degrand.

Couleur.—1°. Pouvez-vous indiquer un moyen autre que l'interposition de verres colorés, pour obtenir, suivant les besoins du service, une lumière de telle ou telle nuance? Cette question nous rappelle que nous aurions dû annoncer et analyser, il y a quatre mois, l'excellente *Chimie pyroetchnique ou traité pratique des feux colorés*, de M. Paul Tessier, (Paris. Dumaine, 1859.) Il y a longtemps que l'idée nous est venue de demander que sur certaines côtes plus inhospitalières on lance périodiquement en l'air des etoiles de couleurs qui puissent être aperçues de très-loin; or, M. Tessier apprend à fabriquer très-économiquement des bombes remplies d'étoiles de l'éclat le plus vif. 2°. Ayez la bonté de rédiger séparément vos avis sur la fabrication des verres colorés, et sur la position à assigner aux verres qui doivent colorer la lumière; on a essayé ou proposé tour à tour l'emploi des cheminées de couleur, des écrans de verre colorés à l'intérieur des lentilles, des lanternes à pans de verre colorés, des combinaisons de chemineés, d'écrans, de lanternes? 3°. Dans votre opinion, quelle est la couleur qui se voit à la plus grande distance, dans tous les états de l'atmosphère, et qui, en même temps, se distingue la mieux des autres lumières colorées et de la lumière blanche? On trouvera dans la brochure de M. Jules Guyot des renseignements précieux sur la lumière considérée comme agent producteur de signaux. Les meilleurs signaux sont ceux qui se peignent en blanc ou en lumière sur un fond noir; les lignes lumineuses sont incomparablement préférables aux points ou cercles lumineux, et nous sommes surpris que l'on n'ait pas demandé encore aux lentiles cylindriques des lignes très-lumineuses; dans la substitution des lignes aux points on gagnerait près de cent pour cent. Après le blanc, les couleurs qui s'éteignent le plus tard, ou à de plus grandes distances, sont l'orange, le rouge et le vert; à quelque distance que ce soit, dans la limite de la visibilitè, on distingue toujours les verres colorés des verres incolores, alors même qu'on ne peut plus caractériser la couleur: cette remarque, due à M. Jules Guyot, est très-importante et peut-être utilisée dans la pratique. 4°. En cas de brouillard, faut-il que la lumière du signal soit blanche ou colorée pour qu'elle soit aussi visible que possible? Si la lumière colorée est préférable, quelle couleur faut-il choisir? Dans notre opinion, la lumière émise directement par la source lumineuse est celle qu'il faut employer; car tous les agents de coloration sont en même temps des agents d'absorption et d'extinction plus ou moins grande. Le brouillard absorbera les éléments plus réfrangibles de la lumière émise, les rayons violets, bleus, etc., et ne lui laissera que les rayons plus réfrangibles, vert, jaune, orangé, rouge; à intensité égale, les lumières vertes jaunes, orangées, rouges, perdraient peut-être moins que la lumière blanche; mais comment dans la pratique obtenir cette intensité égale? Il y a aussi brouillards et brouillards, le brouillard peut avoir une nuance propre, tendant vers le rouge ou vers le bleu; le plus prudent donc, dans tous les cas, sera de garder la lumière blanche. Si on se décidait à lancer périodiquement des bombes remplies d'étoiles de couleur, il fraudait choisir les nuances les plus vive,s et les varier. 5°. Connaissez-vous une méthode à l'aide de laquelle on puisse mesurer la distance à laquelle se trouve une lumière que l'on aperçoit du pont du navire, et vers la quelle on cingle en ligne droite; il faudrait apprécier cette distance dans le cas où l'on connaît la hauteur de la lumière au-dessus du niveau de la mer, et dans le cas où cette hauteur est inconnue? Dès que l'on suppose que la distance à la lumière est assez grande, la hauteur est peu importante. Dans tous les cas, nous sommes certain que le phanoscope de M. Porro, convenablement adapté, permettra de résoudre ce problème d'une manière suffisamment approchée : en faisant appel à notre savant artiste, la commission verra son vœu bientôt rempli.

MÉCANIQUE.—1°. Pouvez-vous indiquer quelques perfectionnements à apporter à la construction des phares à installer sur des points plus ou moins exposés : à la construction des fanaux flottants? 2°. Connaissez-vous quelques perfectionnements à apporter à la construction des lampes, des appareils tournants, ou autres mécanismes employés dans les phares ou pour les feux flottants? Pour les petits feux, nous demandons instamment l'étude et l'essai de la lampe à hydrogène liquide de M. Jules Guyot, parce qu'elle rendrait de très-grands services. Les lampes électriques et les feux tournants ont été longuement et habilement étudiés par M. Degrand : elles sont seules applicables économiquement aux grands feux.

FLOTTAISON.—1°. *Lumière flottante.*—Quelle est, dans votre opinion, la meilleure forme à donner à la coque du navire support du feu flottant? C'est-à-dire quelle forme faut-il lui donner pour qu'il se tienne à l'ancre par tous les temps, dans les positions les plus découvertes, par les marées les plus fortes, les mers les plus houleuses, avec le moins de mouvement ou de déplacement possible, avec le moins de traction possible sur les amarres? Quelques-uns des navires porte-lumière sont plus courts; d'autres plus longs; la coque de quelques-uns est très-arrondie; pour d'autres, la coque est plus allongée; quelques-uns, en raison des courants et des marées, ne se tiennent pas bien à la mer et sont agités de mouvements excessifs; on a conseillé de leur donner une forme circulaire et de les amarrer par leur centre de gravité. 2°. *Connaissez-vous* quelques perfectionnements à apporter au mode d'amarrage des vaisseaux porte-lumière; par quelle partie du vaisseau pensez-vous que l'amarre doive pénétrer; dans quelques cas, [illegible] les ouvertures d'entrée des amarres sont à une hauteur considérable au-dessus de l'eau; quelquefois, elles affleurent avec la ligne de flottaison; on a conseillé depuis de les faire descendre au-dessous du niveau de l'eau? 3°. *Bouées.* Quelle est celle des formes adoptées [illegible] pour les bouées que vous jugez la meilleure, la plus apte à se maintenir par tous les temps, dans les situations les plus exposées, par les marées les plus fortes et les mers les plus dures, avec le moins de traction possible sur les amarres, et qui en même temps soit la plus facile à apercevoir? Avez-vous quelques perfectionnements à proposer dans la forme à donner aux bouées, ou dans leur mode d'amarrage? Quelle forme de bouées adopteriez-vous dans les positions mieux abritées? *Pourriez-vous* indiquer quelque moyen plus pratique et plus avantageux de rendre les bouées lumineuses pendant la nuit? Ici nous déclinons notre compétence en faisant appel aux marins [illegible] *Nous* redisons seulement [illegible] parfait d'éclairage pour les bouées. 4°. *Pourriez-vous* nous indiquer un système généralement applicable [illegible] de bouées ou signaux [illegible] dans les ports, les passes ou [illegible] bancs de sable, des [illegible] cartes et en l'absence des pilotes les vaisseax puissent navigeur e sûreté ? Si vous connaissez un semblable système, ayez la bonté de l décrire et de dire un même temps si on peut le réaliser avec les bouées actuelles.

Acoustique.—Quelle nature et quel timbre de son jugez-vous la plus propre à transmettre des signaux à travers le brouillard ? Quelle est le meilleure manière de produire le son le plus apte à être entendu de loin ? Quel mode de signalement par le son, en temps de brouillard consillerez-vous comme le plus avantageux dans la pratique ? On s'est servi jusqu'ici de cloches mises en branle par des machines, et de canons; on a eu recours à des réflecteurs ou à d'autres combinasions pour diriger et condenser le son; on à proposé d'employer des sifflets à vapeur, etc., etc.? Il y a encore beaucoup d'expériences à faire, avant de pouvoir donner à ces questions une réponse satisfaisante. Nous dirons cependant, dès aujourd'hui, qu'un son grave, continu, d'intensité relativement médiocre ou qui soit sans éclat, a beaucoup plus de portée qu'un son aigu, rapide, très-fort. Des éclats de foudre dont le bruit formidable, entendu à proximité, à été quelquefois comparé à la détonation de cent pièces de canon éclatant à la fois, ne se propagent pas à des distances de plus de 16 à 24 kilomètres, tandis que le bruit du canon s'entend quelquefois à 80 et 120 kilomètres. Un timbre de très-grand diametrè, mis en vibration par un archet mû mécaniquement, et dont le son serait renforcé par un gros tube placé en arrierè du timbre. mériterait d'être essayé. On pourrait tenter aussi la construction de bouches à feu dans lesquelles des mélanges détonants d'hydrogène ou de gaz d'éclairage et d'air remplaceraient la poudre à canon. M. Marloye proposait de substituer aux plus grosses cloches, même aux bourdons, des triangles d'acier rendant des sons très-intenses et très-graves sous la percussion d'un martéau. L'adjonction aux cloches de tubes renforçants n'a pas encore été faite, et mérite de l'être ainsi que nous l'avons dit dans le tome II, de l'*Annuaire du Cosmos.*

2°. Quel moyen conseillez-vous pour concentrer le son, ou pour l'envoyer dans une direction donnée? Pensez-vous qu'il existe une méthode à l'aide de laquelle les marins puissent distinguer, avec une certitude suffisante, la direction dans laquelle un son est engendre? Les réflecteurs du son, dans notre opinion du moins, sont et seront complément inefficaces. La seule manière de condenser le son est le tube renforçant aujourd'hui sans application, et qui aurait, en outre, l'avantage de mieux imprimer au son une direction dans le sens de l'axe du tube. Nous sommes enclin à penser qu'en s'armant les orielles d'un double stéthoscope semblable à celui que M. Scott Alison a décrit sous le nom de stétophone différentiel dans, le *Philosophical Magazine* de Novembre, 1858 on arriverait à discerner la direction de le source du son d'une manièr presque infaillible. Il serait important aussi d'essayer le pouvoir co ducteur et condenseur de l'eau mis un évidence par les expériences MM. Colladon et Sturm, et de M. Alison.

3°. A quelle hauteur faut-il placer le signaux sonores des temps brouillard, pour qu'ils soient entendus à la plus grande distance p ble? Nous n'hésitons pas à dire que les sons doivent être produits surface de l'eau qui servira de plan réflecteur et directeur; mieux v drait encore peut-être le produire dans l'eau, où il serait comme em *sonné.* Ajoutons que si chaque station de signal a son son propre ton déterminé et connu à l'avance, l'appréciation facile de ce son, à l'aide de boîtes à résonnance comme sait si bien les faire M. Kœnig, serait le meilleur moyen de détermination du lieu, origine du son signal.

Météorologie.—1°. Aquelle hauteur est-il désirable que les becs lumineux soient placés en général, sur les côtes des royaumes-unis, en tenant compte de ces faits : que, plus la lumière élevée, plus est grande la distance à laquelle les rayons parviennent, avant d'être interceptés par l'horizon ; que, plus la lumière est basse, moins elle est exposée à être obscurcie par les nuages ? Nous pencherions pour une hauteur aussi grande que possible, en raison des brumes ou brouillards qui règnent trop souvent à une faible distance du niveau des mers.

2°. En supposant que la télégraphie optique soit étendue à quelques phares at à quelques vaisseaux à feux flottants près des points le plus saillants des côtes ; quelles sont les informations météorologiques qu'il importe le plus de transmettre aux vaisseaux en vue ; comment et sous quelle forme ces informations peuvent-elles être reçus et transmises par les gardiens des feux ? Les informations les plus importantes seront évidemment, lorsque le nouveau service sera établi, celles relatives aux ouragans et aux tempêtes apparus dans des parages plus ou moins éloignés, et yui menacent de s'étendre aux régions vers lesquelles les navires font voile. Quant au mode de transmission ou de réception de ces signaux, nous en connaissons rein de mieux étudié que la télégraphie de nuit de M. Jules Guyot.

3°. *Signaux de marées.*—Quel système recommandereiz-vous comme devant être adopté généralement dans les phares ou sur les vaisseaux à feu placés à l'entrée des ports, pour l'indication de l'état de la marée le jour et la nuit aux personnes naviguant au large ? Divers systèmes comprenant des ballons, des pavillons, des lumiéres colorées, des figures illuminées mises en mouvement par le flux ou reflux, sont aujourd'hui employés ou proposés ? Le systéme de signaux si ingénieux et si efficace de M. Sudre n'a pas reçu, il nous semble, toute l'attention qu'il mérite, et nous le croyons bien préférable aux imitations que nous avons vues mises à l'essai l'année dernière sur divers points, en Angleterre et en Amérique. Nous avons suivi de très-près, a Edinbourg, la manœuvre du ballon installé sur le monument de Nelson, et qui doit simplement signaler l'heure aux vaisseaux des ports voisins ; or, cette manœuvre nous a semblé bien complexe, bien absorbante ; ne pourrait-on pas atteindre le même but beaucoup plus simplement ?

4°. Connaissez-vous, ou pourriez-vous indiquer une bonne méthode de constater l'individualité des phares ou des vaisseaux à feux flottants pendent le jour ? Pourriez-vous indiquer quelques perfectionnements au procédé par lequel on s'assure de cette individualité pendant la nuit? Si nous avons bien compris, il s'agit de savoir quel est le phare ou le feu flottant que l'on a actuallement en vue, ou, ce qui revient au même, le point sur lequel le phare ou le vaisseau sont placés. Si c'est bien là la question, nous dirons nettement que la meilleure solution du problème est celle proposée par M. Babbage, l'illustre membre de la Société Royale, qui, par des moyens très-simples, fait signaler au loin, par chaque feu, son numéro d'ordre ou son nom. Nous ne comprendrions pas que ce perfectionnement considérable eût été ajourné jusqu-ici, s'il n'était pas trop vrai que nul n'est prophète dans son pays.

Telles sont, à première vue, les résponses que nous croyons devoir

faire à la consultation qui nous est adressée. Nous la résumerons en distant que si la commission Anglaise tient à s'aider des lumières de la France, et de la expérience acquise parmi nous, elle devra se mettre en rapport, pour la télégraphie optique de jour et de nuit, avec M. le docteur Jules Guyot; pour les phares, source lumineuse, lentiles et échelons réflecteurs avec M. Degrand; pour le télégraphic accoustique, avec M. Wertheim; si elle suit nos indications, elle avancera considérablement sa besogne, et remplira mieux sa grande mission tout humanitaire.

P. S. Les machines magneto-électriques de la compagnie l'Alliance ont atteint une perfection telle, que la lumiere électrique est en ce moment la plus intense et la plus économique de toutes les lumières. Le regulateur de lumière électrique de M. Serrin, adopté par la compagnie l'Alliance, est aussi absolument parfait, sa lampe s'allume, se maintient allumée, se rallume elle même sans aucune intervention de la main de l'homme; c'est la solution la plus complete d'un difficile problème.

F. MOIGNO.

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CIRCULAR No. II.

James T. Chance.

I. *a.* Yes. The apparatus should generally be so adjusted that the rays from lines in the flames through the respective foci of the prisms and lenses shall constitute the light seen at the farthest distance. This adjustment depends upon the elevation of the apparatus.

b. Yes. The maker might frequently suggest improved arrangements, especially for the purpose of making use of that part of the flame which is towards the arc of the horizon *not* required to be illuminated.

II. This information need not affect the prisms and lenses. The required adaptation can be perfectly accomplished by *inclining* the *prisms*, and *depressing* the *lenses*, in their respective metal frames, to a *very slight* extent, varying as the square root of the elevation. The lenticular panels ought, at the same time, to be inclined outwards, so that the focus of the lenses shall remain on the same point of the flames as before the lenses were depressed.

III. Yes; but no maker ought to require any such table. I do not see the applicability of any table to different horizontal arcs.

IV. No.

I. Alan Stevenson, L.L.B., F.R.S.E., lately Engineer to the Lighthouse Board in Scotland.

I. There are a few situations near to towns in which gas might be used, especially in dioptric lights, whether fixed or revolving; but its application to catoptric illumination would apply only to fixed lights As to the oxy-hydrogen and magneto-electro lights, my own experience gives me no means of offering a decided opinion. (My Rudimentary Treatise on Light-houses, p. 60, Part I.)

III. My own experience leads me to reject any mode of illumination but oil for lights in difficult and inaccessible situations.

IV. There can be no doubt that the polyzonal lenses invented by Buffon and Condorcet, and again by Fresnel, who reinvented them, and first applied them to light-houses, are the best instruments for revolving lights; and more especially is this true when their effect is extended beyond the simple dioptric action, by means of catadioptric zones of a curved form, concentric with the zones of the lens, and removed behind them so as to intercept the rays which would escape above and below the lenses. This arrangement was first suggested by Mr. T. Stevenson, and used for a first-class light at North Ronaldsay, in Orkney.

V. The dioptric arrangement of Fresnel with diagonal joints, or rather helical joints, like those first used in renovating the Isle of May light, in 1836, is by far the most suitable, and seems the only one capable of fully meeting the requirements of a fixed light on a large scale.

VI. I have never had that subject under my particular consideration.

VII. *d.* I strongly recommend the use of *diagonal* framing for the lanterns instead of *vertical*, as the light is thus equalized in every azimuth. This was first done, on the large scale, at Noss Head, in Caithness.

X. I know of no colors except *red* and *green* which can be used with advantage.

XI. I know of none that would be of the slightest use in practice.

XII. I think stone buildings should always be preferred. All experience goes to condemn the use of iron in exposed situations, which must daily deteriorate in its strength and in its fixtures. For such purposes I think *weight* a far more legitimate source of stability than *strength.*—See my Rudimentary Treatise on Light-houses, p. 55, Part I., and 180, Part III., also Part I. p. 25, et seq.)

XVIII. I have no great confidence in any mode of employing sound, either with the expectation of condensing or directing it.

XXII. I think there is rarely much need to seek a higher elevation for the lights than 150 feet.

XXV. *b.* I decidedly prefer the mode used in Scotland to that based on minute subdivision of time. Upon this subject much ingenious but useless speculation has found favor with persons unacquainted with practical seamanship.

I. Thomas Stevenson, F. R. S. E., President of the Royal Scottish Society of Arts, and Joint Engineer to the Board of Northern Light-houses.

II. In the present state of our knowledge I am not prepared to state that there is any better source of light than oil.

IV. The most perfect is that in which the revolving lenses of Fresnel are combined with the totally reflecting holophotal prisms which I proposed for light-houses in 1849. The first application of total reflection to *revolving lights* was adopted at Horsburgh, near Singapore, in 1851, and afterwards on the large scale at North Ronaldsay.

Since 1851 I have used for lights of a small scale, as at Morecambe, &c., annular lenses cast in one piece, having the curved surfaces of the central part and also of the outer rings unground and unpolished.

I do not, however, *think that for sea* lights any plan, however cheap, should be adopted, which intercepts any considerable portion of the rays which would have been usefully transmitted had the surfaces been polished. The full effect of the oil consumed should not be diminished by the interposition of apparatus of second-rate quality, by which the seaman is in perpetuity deprived of a portion of the rays proceeding from the combustion of the oil, for the whole of which he has to pay; and though stamped lenses and reflecting prisms may, as I understand has been done in France by M. Degrand, be made much thinner than those which are ground and polished, and may thus prevent much absorption of light, still I should fear that their surfaces would be inferior in polish and accuracy of form, thereby causing irregular dispersion. It is proper to state, however, that I have not seen any of the French cast lenses, which are probably very superior in quality and in other respects to the small ones made for me in this country for harbor lights.

V. The fixed dioptric light of Fresnel, as used in the northern light-houses, with diagonal framed lantern, is the most perfect fixed-light apparatus that I am acquainted with. When the light does not require to be seen all around the horizon, or in equal strength in every azimuth, I recommend what I have called the *azimuthal condensing light*, by which the light can be so allocated as that its power in different azimuths shall be proportioned to the distances that the light is expected to be seen in those azimuths. This arrangement was proposed in 1855, and introduced in 1857 at Isle Oronsay and other Sound lights, where a great saving of oil has been effected.

VII. *d.* The apparatus in nearly every case may be placed with its axis truly horizontal, but in very high lights the lenses, &c., should be made to dip till their axes intersect the horizon line.

IX. The red chimneys used in the northern light-houses are first made of white glass, and then stained red, but Messrs. Stevenson have lately been experimenting on some blown directly from red "metal" at Messrs. Chance's works, which have answered remarkably well, and are expected to be very considerably cheaper.

a. Red chimneys have been long used in the northern lights' service for Argand burners, and experiments have just been completed by Messrs. Stevenson on similar red chimneys for *four-wicked* burners, the results of which are quite satisfactory. When the light is to be all red, the chimney is the best agent, but when the light is to change from one color to another in certain azimuths, the colored medium must be removed as far as possible from the radiant to increase the sharpness of the "*cut off.*" When plate-glass can be produced of the proper tint, sufficiently thick for *glazing the lantern*, it is much to be preferred.

X. *a.* In the order of their visibility, white, red, green, blue; but the green, and especially the blue, greatly diminish the power of the light, and should be very sparingly employed.

b. If the radiant be of the same power, white light is certainly the best, as though a fog has the property of imparting a reddish tinge to white light, it probably never obstructs all the other rays of the spectrum. If, on the other hand, the *red light* be of the same intensity as the *white light*, the advantage is on the side of the red light, as I understand has been proved by MM. Reynaud and Degrand by experiments.

XI. I do not know any satisfactory method.

XII. In certain circumstances a revolving light may be made azimuthal, condensing when the light does not require to illuminate the whole horizon; the power being increased in the required directions by applying mirrors, which are made to move when they come to the dark or landward part of the lantern, where they will alter the direction of the rays; but this arrangement is not capable of being adopted in all circumstances.

I beg to refer to the drawings of beacons and light houses which have been furnished by the Northern Lights Board to the Royal Commissioners.

XIII. I believe the lamps, &c., in the Northern Lights' service to be constructed on the best known principles.

XVI. c. The most promising method that I know of is to direct a powerful beam of light upon them from some station on shore; the buoys might also be furnished with reflecting or refracting agents

In experimenting lately on an apparent light proposed for illuminating an inaccessible beacon, a powerful beam of very slightly divergent light was produced by glass prisms, which were more than *half a mile* distant from the source of light, which consisted of a large annular lens, illuminated by a single Argand burner only one inch in diameter

XVII. The first proposal for this purpose that I am aware of is that by Captain Bedford, and adopted and extended by Mr. Alexander Cuningham, and referred to in his report to the Commissioners of Northern Lights, in 1858. My impression is that the system of adopting four colors to represent the cardinal points of the compass, as was at one time proposed by Mr. Cuningham for off-shore dangers, is the best system, and should be extended to all buoys, and to beacons also, whether they be placed in rivers or at sea. The intermediate bearings could be indicated by stripes of two colors, or otherwise.

XVIII. I am unacquainted with any satisfactory method of employing sound.

XX. I know of no way of enabling the mariner to tell with certainty from what direction a sound comes.

XXII. On the Scotch coasts, especially in the neighborhood of high land, I think it is not desirable to exceed a height of about [illegible] feet

XXIII. The only intelligence I can think of is the occurrence of storms at other parts of the coast, but I think it would be difficult to communicate with ships at sea.

XXIV. Mr. Alexander Cuningham's code seems to promise well.

[illegible]

I. It is absolutely necessary that the information alluded to [illegible] accompanying queries should be obtained previous to the [illegible] of the apparatus. In our experience we find that the [illegible] almost all lights essentially those [illegible] lenticular apparatus has [illegible] combined with auxiliary agents [illegible] quirements peculiar to the locality [illegible] manufacturer, and which if neglected [illegible] utility of the light to the mariner [illegible] Northern Lights, and others whom [illegible] houses contrast [illegible] order, therefore, that all offerers may base their tenders on the same data, and so engage in a fair competion, it is absolutely necessary to furnish them with a *plan* and *specification of the work to be performed.* The plan and specification embrace the information referred to in the queries, so that the only duty of the manufacturer is to see that his own department is fulfilled, and that the work is executed in terms of the specification. Without such a plan and specification it is not possible always to secure good work, and it is not at all unlikely, when there is no regular plan and specification, that a *high* price has to be paid for *inferior* workmanship, without the power of being able to check it. Further, we have often, even with a specification and plan, had occasion to reject, in whole or in part, apparatus furnished by the most respectable houses, which without the plan and specification as a standard of reference, we could not have insisted on, but must have been contented to take the contractor's explanation of what he conceived to be the quality of work required, and on which *vague* conception he had made his offer.

A light has often to be cut off, or its color changed, or its intensity increased in different azimuths, all of which must be considered by those who design the light, and the desired effect can only be attained by actual trial and adjustment of the light itself as viewed from the sea, which obviously cannot be intrusted to the manufacturer.

From what we have said it will, therefore, be seen that we do not consider that it would either be economical or desirable, or even in many instances possible, to entrust the manufacturers who offer for the work to arrange its details and style of workmanship, and, therefore, we conceive that the proper course, in order to ensure the *best workmanship*, at the *lowest cost*, is that which we invariably follow, viz., to take all such details as those specified in the queries into consideration when preparing the plans and specifications which regulate the carrying out of the contract between the parties, and in terms of which the different contractors make up their offers, and thereafter execute the work.

NOTE AS TO APPARATUS FOR THE ELECTRIC LIGHT.

Having never had an opportunity of seeing the magneto-electric light, I shall not attempt to give any design for its apparatus, but I think it right briefly to describe certain optical instruments, some of which may be useful for lights, such as the electric, which, from the small volume of the radiant, possess very small divergence.

Where additional *horizontal* divergence is required for revolving apparatus, I would recommend the spherico-cylindric lens which I proposed for light-house illumination in 1856. Where, from the tower being elevated much above the sea, increased *vertical* divergence is also required, I would propose, as probably a better arrangement than merely depressing the spherico-cylindric lens, a new form, which might be called a *differential lens*, from the property it possesses of allowing the amounts of vertical and horizontal divergence to be adjusted in any required ratio. One side of this differential lens would resemble Fresnel's lens, in having surfaces curved spherically, while the other side, instead of being plane, would be ground to a double curvature, the one horizontal, to produce the necessary azimuthal divergence, and the other vertical, to give the necessary dip. In fixed lights, the central refracting belt may be corrected for dip by a slight vertical curvature on the inner side.

As it is probably impossible to give any additional curvature to the totally reflecting portions of the apparatus, the rays, after passing through the ordinary apparatus, might pass through *differential refractors* placed in front. One face of each refractor would be straight vertically and ground to such a curve horizontally as would give the incident rays the required amount of azimuthal divergence, while the other face would be straight horizontally, but would be curved vertically, so as to give the necessary amount of dip. Similar refractors, circular in plan and curved in the vertical section, to give the required dip, might be constructed for fixed lights, or, to dispense with an additional refracting medium, the glass panes of the light-room might be so as to answer the same purpose, the horizontal curvatures being omitted. These refractors might have different curvatures, so as to allocate the quantity of the light to be sent in different vertical sectors proportionally to the distances from which the light requires to be seen in such sectors.

In azimuthal condensing lights, whether fixed or revolving, the straight prisms which form part of the auxiliary apparatus might, where the height of the tower renders it advisable, easily be ground for the dip to a vertical curvature on one side.

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I. S. Barrass, C. E., 5 Culford Grove, De Beauvoir town, London, N.

XI. An instrument may be made to determine the distances of lights as soon as they are visible, and irrespective of their height, on the geometrical principle that the angles at the base of an isosceles triangle are equal, and on the optical principle that the angles of incident and reflected rays are equal. Thus, let an instrument be constructed with a fixed reflector and a movable one, the latter having an arm or lever with a graduated scale and vernier, and a magnifier for reading off as in the quadrant, or the index glass may slide at right angles to the axis of the vision, and then equal divisions of the scale and vernier will represent equal distances from the observer, the horizon glass being silvered half way up, and having a small telescope to assist the sight, in the usual manner of optical instruments for taking observations.

XII. *a.* I beg to draw the consideration of the Royal Commissioners to a means of constructing light-houses in exposed situations, and applicable to many where floating lights are now moored, it being premised that a light-house will always be preferred to a floating light, wherever it is possible to substitue the one for the other.

This means is by sinking large wrought-iron cylinders or caissons in the position required, excavating the interior until a good bottom is found, or a foundation formed, filling up the void with concrete, and then erecting thereon a stone or iron tower, according to the funds at command, stone forming an unexceptionable tower, but iron offering a cheaper course of construction, while the caisson may be carried 20 or 30 feet above high-water level, and form a breakwater to protect the tower in rough weather, and in fine weather a terrace for the recreation of the keepers, while, if necessary, it might be made an element in the means of rescuing life from shipwreck.

The writer endeavored, some ten years ago, to draw the attention [illegible] the authorities concerned to this proposition, but the sinking of cyli[illegible]ders for foundations was then, comparatively speaking, in its infanc[illegible] Nothing had been attempted beyond cylinders of six and seven fe[illegible] diameter, while Dr. Potts's experimental beacon at the South Callip[illegible] Sands had but recently proved a failure—a failure which might ha[illegible] been anticipated, seeing that the cylinders were merely stuck in th[illegible] sand, and had no foundation. Now, however, by the introduction [illegible] the system of working and excavating under a pressure of air, usi[illegible]g the cylinder as a deep diving-bell, exposing to view the whole area [illegible]f the bottom, and so offering every facility for procuring a good found[illegible]tion, the probability of failure, if the works are properly and cautiously conducted, is exceedingly remote.

The wrought-iron caisson for the centre pier of Saltash bridge is sunk to a greater depth than would be required for a light-house in the position of the Gull Stream floating light, its diameter is nearly enough for a first-class tower. The cylinders for the bridges recently erected over the Nile are sunk from 90 to 100 feet below the water level.

The Gull Stream light is moored in 54 feet, the bottom sand and shingle, the nearest chalk soundings 62 feet, no doubt the solid chalk formation as in the adjacent coast. The South Sand head light is 84 feet, nearest chalk 95 feet. The North Sand head light is 60 feet, chalk probably at 75 feet. The Nore light in about 30 feet, and the two Formby Channel lights and the Northwest light-ship in about 40 feet.

There is every probability that in any of the above positions, where the sands and channels are sufficiently permanent to justify the erection of a tower, a light-house could be erected, the ultimate possibility being determined by sinking a small experimental cylinder to see if a bottom can be found or a foundation formed at a depth which can be reached by the workmen.

b. The above system is believed to be eminently adapted for beacons in sands, silts, or loose earthy bottoms in exposed situations. A series of small cylinders may be sunk until each is properly placed on a foundation, then filled with concrete, and braced together in the superstructure.

XVI. *a.* Buoyage.

The forms of buoys in present use, and those proposed which have come within the cognizance of the writer, are ineligible for the purpose intended, their excessive motion rendering any distinctive mark upon them (when visible at all) impossible of identification.

I beg to suggest that buoys be constructed of two separate but integral parts, one part to give flotation to the entire mass, and another part to always stand vertically, (or nearly so,) and be the signalling object.

This I propose to effect by having an aperture in the centre of the floating part, (which may then be a right-lined figure instead of a peg-top form,) through which to pass and hang in swivels, the vertical part, which is to form the signal, passing it into the water a certain distance and weighting it at the bottom to keep it steady and vertical, and allowing it to stand above the water surface, say 15 feet, or other suitable height, according to circumstances. The method of mooring should be with three chains.

b. The above description of buoy is believed to be equally eligible for sheltered situations.

XVII. Yes. I beg to suggest that on the top of the aforesaid vertical signalling part of the buoy there be fixed large block Roman numerals, say 10 feet high, indicating the depth of water at that point as fathoms of water, while rocks and shoals might have their initials fixed. The buoys being so moored that they cannot turn round and present the edge of the letters or figures. Could be applied to buoys now in use.

XIX. A bell, similar to those of clocks and alarms, but of sufficient magnitude to be heard one or more miles.

XX. Placing the bell in the focus of a paraboloidal reflector. Yes; making the bell to revolve and strike a given or certain number of times in one revolution, when the maximum and minimum or varying intensities of sound would indicate the line or direction of the signal.

XXI. The surface of water is probably (if not absolutely) the best conductor of sound, and a fog-signal should, therefore, be placed on a separate gallery, (instead of the gallery around the lantern,) and as near the surface of the water as is practicable, having due regard to the height which heavy spray may be thrown during the period of fogs, say about 30 feet above Trinity datum or high-water level.

XXV. A good system of identifying light-houses and floating lights by day may be effected by coloring the body of the tower of the former and the side of the hull of the latter in large patterns, consisting of the three simplest geometrical figures, the square, the triangle, and the circle, with the three primary colors, red, blue, and yellow, together with black and white. Floating lights having their mast signals agreeing in shape and color with the pattern on the hull.

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(Translation.)

G. Magnus, Berlin.

V. If there be placed before a lamp, or any other source of light, at the focal distance, a cylindrical lens which is bounded by one plane and one cylindrical surface, or by two cylindrical surfaces, the axes of which are horizontal, the rays proceeding from the source of light in a vertical plane perpendicular to the axis of the lens are parallel to one another. If we now suppose the lens curved, so that it stands at the focal distance in each vertical plane that passes through the source of light, the rays proceeding from the lens so curved fill a space which is bounded above and below by parallel surfaces, and on either side by planes which pass through the source of light and the vertical edges of the lens. If the lens be so placed that these rays stretch away over a part of the surface of the sea, the light is visible to all vessels that arrive within that space. It will not be possible with a single lens to illuminate a very large surface of the sea. This object can be attained only by means of several such lenses, placed over one another in two rows in such a manner that those of the upper row should be situated above the interstices of the lower. It is self-evident that then each lens, or at least each row of lenses, must have its peculiar source of light, and that the two rows must be inclined somewhat differently.

Such double curved cylindrical lenses, if they do not require to be too much curved, might be made according to the following method given at VII e:

A strengthening of the light might still be attained by the placing of concave mirrors behind the plane of each lamp. It is superfluous to mention that these must be brought into such a position that the flame is in the central point of the mirror.

VII. *c.* Lenses may be constructed of sheets of glass fixed together, between which water or some other fluid is placed. In order to give the necessary curvature to the well-ground and polished sheets, there must be prepared in iron a segment of a sphere of the size and curvature which the lens should receive. This segment is placed in a great muffle, or a suitable reverberatory furnace, the sheet of glass is laid on it and heated till it becomes soft. Thus it sinks down on the spherical segment and takes its form, especially if the curvature be not too great. Two sheets thus curved, or one curved and one plane, may be adjusted with their edges in a setting of metal, and the space between filled with water or some other fluid through an opening in this setting. Since at present very large sheets of glass are prepared, very large lenses may also be obtained.

XVI. *c.* For the illumination of buoys at night the electric current may be employed. The buoy must either be wholly of glass or it must carry a water-tight lantern, which always assumes the highest position as well when the sea is high as at its ebb and flow. Into this lantern must be hermetically fixed a cable containing two wires, through one of which the current flows to the buoy, and through the other back from it.

The so-called electric or coal-point light is, on various grounds, not applicable. But a fine platinum wire stretched between the two conducting wires may be maintained at a white heat by a constant current, or, what is better, an induction apparatus may be employed, and by means of it a Geissler's tube may be rendered luminous. If the rarified space through which the stream passes in such a tube is of very small diameter, the light that this space sheds abroad is of extraordinary intensity.

I. The Earl of Rosse.

I have not had sufficient experience at sea to be enabled to speak with confidence upon any of the points raised in these questions, and although I venture to make a few suggestions, it is more, perhaps, with the view of showing an anxiety to co-operate in every way in my power with the Royal Commissioners, than in the expectation of being able at present to propose anything useful.

II. The electric, the oxyhydrogen, and the oxycalcium lights far surpass in brilliancy the best oil and gas lamps, and if not too expensive there seems to be little doubt they might be advantageously employed in light-houses. The experiment at the South Foreland will, I presume, decide the question as to the electric light. The only inconvenience which I have experienced in some experiments with the lime light arose from the occasional splitting of the lime cylinders. They are usually turned out of solid lime, with a central hole drilled out. We found that they might be quickly made with powdered lime driven over a *piercer* in a brass mould like a rocket. To prevent the lime from adhering to the brass, a thin card was interposed. In the limited experience we had, these cylinders did not crack. As to the expense, the principal item would be the light expended in producing the necessary amount of divergence, and that would depend upon circumstances.

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III. I do not think there would be much difficulty in making one or indeed both gases in a light-ship.

IV. I think a well-made parabolic reflector. Almost all the light, indeed, all the light where a lime cylinder is employed, is received by a parabolic reflector of sufficient size, and silver reflects about 92 rays in a hundred.

V. The dioptric apparatus.

VII. The present mode of figuring parabolic reflectors appears to me to be very defective. The paraboloid is a figure of revolution, and it can best be produced by turning. A cutting point guided by a parabolic templet would give, in my opinion, a paraboloid very superior in accuracy to one produced by any process of hammering, as at present. The templet might be made in different ways. For instance, a cone can be produced by the lathe with extreme accuracy, and therefore a section of a cone. The reflector must be cast of gun-metal turned, electro-plated carefully, and finally finished in the lathe. The increased accuracy would only tell, however, in the case of a small source of light, or the central portion of a large one.

IX. Possibly in some cases it might be important to be enabled to identify a light with certainty, even at long intervals, say half an hour. A small cartridge of strontian fire would probably effect that object, and self-acting apparatus could obviously be contrived for producing the ignition at the required interval. Where there were several oil lights, to make one a lime or electric light, would, I should think, completely identify it.

XI. In the first case, I know of no shorter or better method than that given in the Scientific Manual. In the second case, photometry appears to me to offer the only chance of even a rough solution of the question practically applicable. If the intensity of the light and transparency of the air were nearly constant, a scale of distance might be made connected with the thickness of tinted glass required for the extinction of the light. The practical arrangement would be a telescope furnished with a wedge of tinted glass giving motion to a scale. I have, however, had no opportunity of trying the experiments.

XIV. It appears to me that the form should in some degree vary with local circumstances. For instance, if with the aid of a suitable rudder the vessel can be made to ride head to wind, then it should be long, sharp, and of such lines as to roll least. On the contrary, if the strength of the tide is sometimes overwhelming, and means cannot be found by extra moorings or otherwise to keep the vessel head to wind, there seems to be no alternative but a very large beam. A circular vessel would obviously be in great danger if driven from her moorings. If the Commissioners have not yet examined Mr. Babbage's suggestions for improving light-houses, I think it desirable that they should do so, as he is a man of great knowledge and great inventive powers. I am not, however, sufficiently acquainted with his views to be enabled to give a practical opinion on the subject.

* * * * *

I. George Gladstone, of 8 Austin Friars, London.

II. I have never seen the South Foreland magneto-electric light, but I have heard it most highly spoken of by shipmasters and others.

X. *a.* Of colored lights, red and green present the greatest contrast, (to those, of course, who have a true perception of color,) and at the same time are the most readily distinguished from white light. I think, however, that the colors generally adopted are of too deep a shade. If the green contained less blue, and the red more nearly approached a scarlet than a crimson, the contrast would be more marked, and less light would be absorbed, so that they would be visible at a greater distance.

b. White light can be seen at a very much greater distance than the same light colored by glasses, especially during a fog, colored lights being visible only with great difficulty under such circumstances.

XIV. Not circular. This form will present the greatest possible resistance in proportion to its size, so that I doubt whether any ordinary moorings would hold a vessel of sufficient size of this form. The resistance of any vessel is dependent on the midship section, so that you can lengthen a vessel almost indefinitely without materially increasing the resistance, (the increment in such case being principally due to mere friction,) provided you do not alter her beam, and as the longer she is the sharper you can make her, I would suggest a long vessel with small beam, with a fine entrance, but full in the run, only just tapering sufficiently to avoid friction of the water against the ship's side. The fineness of the entrance would reduce the resistance as much as possible. The length of the vessel would tend to her steadiness and ease of motion, and the heaviness of the run in proportion to the entrance would keep her head well up to the sea.

XV. The hawse holes should be near the water line, and only a short distance in front of the centre of displacement, so as to avoid the strain caused by the pitching of the vessel, which would necessarily be increased the further they are carried forward.

XXI. Close to the surface of the water, as that will prevent the sound from spreading, (as far as possible,) and as all sounds have a constant tendency to rise, it would soon be lost to those on board a vessel if it originated from any elevation.

XXII. The light should, in my opinion, be placed as high as possible. There is frequently a dense fog near the surface of the water, while it is perfectly clear above, and I think a low light is nore likely to be obscured in this way than one in a high situation is by the lowness of the clouds, and as a good white light can be seen from a ship's deck in ordinary weather as soon as it rises above the horizon, the higher it is placed the more useful it will be.

XXII. Telegraphic communication may be extended to many of the light-houses around the coast with most beneficial results. Many of the disasters which take place arise from the ships being overtaken by severe weather before the crews have had time to prepare themselves against it.

The keepers of the light-houses which are in the most favorable situations for making meteorological observations might be instructed to watch the approach and course of storms, and to communicate at once by electric telegraph with the other light-houses which are likely to come within the range of the storm, and by a code of signals the information could be communicated to all the vessels within sight. By these means it would be very easy to tell the shipping in the neighborhood from what quarter and how soon a storm might be expected, as each light-house keeper could be informed of the state of the barometer, as well as the direction and rate of the wind at the other points of observation, and by comparing them with his own observations, will be able to calculate its approach with tolerable accuracy.

A military committee, which is now sitting at the War Office, Whitehall, of which Deputy Quartermaster General Gordon is the secretary, has been considering the establishment of some military observatories, probably under the charge of the Corps of Engineers, at some salient points of the coast, to be connected with headquarters by telegraph wires; and it has been suggested by this committee that it would be highly advantageous if such officers were at the same time to keep a regular daily meteorological register, and transmit their observations from time to time to Rear Admiral Fitzroy for permanent record, while any important atmospheric disturbances should be immediately communicated by telegraph to the Downs, Lloyd's, Liverpool, and other places of importance to shipping. It seems probable that this suggestion will be carried out, and the scheme would be rendered much more complete were several of the most important light-houses around the coast to be brought into *rapport* with these military stations. As the light-house keepers have many other important duties to attend to, it would not be desirable to tax them with so many details as may reasonably be required of the military establishments.

The necessity in the case of light-vessels swinging at their moorings, and of having at times a good length of cable out, seems to me to preclude the possibility of establishing telegraphic communication between them and the shore. In some cases, however, it might be arranged to convey the information to them by signals from a station on the mainland, to be repeated by the man in charge of the light-ship, for the benefit of others that may be at a greater distance.

I. William Braham Robinson, Esq., Senior Assistant Master Shipwright, Sheerness Dockyard.

IV. The dioptric system appears the best. The light should reach its brightest state once every minute.

VIII. No.

X *a*. Green. This opinion is formed from having attended trials of bow-lights for ships.

b. White light.

XIV. A light-vessel, in an exposed position, is liable to break from her moorings, and therefore to be exposed to shipwreck; she should, consequently, be fitted for sailing or *steaming*. Length conduces to the reduction of the pitching and ascending motions, and a moderately deep draught of water imparts lateral resistance, and consequently tends to lessen the rolling motion. As a ship always displaces a quantity of water the weight of which is equal to that of herself, it follows that after she is inclined from the upright position the water she displaces will be exactly equal to that displaced before the inclination, therefore, the solid contents of that part of the body immersed is equal to t solid contents of that emerged by the inclination; but the forms of t solids immersed and emerged are not necessarily alike, and, if not simil the axis of rotation, and therefore the centre of gravity of the shi must rise or fall during the inclination and return to the upright pos tion. From this, it will be seen that the centre of gravity of the shi in a vertical sense, and the axis of rotation, should coincide with th water-line, to ensure an easy rolling motion. Also, a light-vessel shoul have a sharp bow, as experience shows that sharp-bowed ships requir less heavy anchors to hold them than, *cæteris paribus*, full bowed one do.

XV *b*. Just above the water line.

XVII. The buoys now in use might, by coloring them, be made appl cable for buoying coasts, harbors, rocks, shoals, and channels. A blac buoy being kept, to carry a vessel out of danger, bearing north, a whi one south, a red one east, and green one west; and a buoy to be ke bearing N.E. might be painted black and red, and one required to b kept bearing S.E., white and red, and so on, with S.W. and N.W.

* * * * *

CIRCULAR II.

PARIS, *le* 29 *Juillet*, 1860.

Degrand, Ingénieur des Ponts et Chaussées, 11 Rue Louis le Grand.

I. *a*. Il n'y a utilité à indiquer au constructeur la hauteur du pha que lorsque cette hauteur doit être considerable et d'épaisseur, par e emple, 150 or 200 pieds. Au-dessous de cette limite les dispositions l'appareil restent exactement les mêmes quelle que soit la hauteur la tour, et le constructeur n'a pas intérêt à la connaître; au contrai lorsque la hauteur est plus grande et surtout lorsque le phare doit êt situé, par exemple, sur des falaises, élevées, une côte montagneuse, & il devient nécessaire d'incliner légèrement les lentilles et de relever lampe placée au foyer, et dans l'interêt de la bonne construction l'appareil, il convient que la constructeur soie prévenu d'avance. Il sans dire que la hauteur du phare doit toujours être comptée à part du niveau de la mer.

b. Il est toujours nécessaire d'indiquer d'avance au constructeur l'a gle exact de l'horizon à éclairer.

II. Lorsque les appareils lenticulaires doivent présenter les dispo tions adoptées en France il n'y a nul intérêt pour le constructeur à co naître la hauteur du phare et l'angle à éclairer avant de tailler l prismes entrant dans la composition des lentilles.

Le travail de ces pièces est dans tous les cas le méme.

Mais si l'on adoptait des combinaisons nouvelles de lentilles, com par exemple dans le but de concentrer toute la lumière d'un phare s un point déterminé, de la diviser en deux ou plusieurs faisceaux suiva des directions spéciales, &c., il serait nécessaire pour le construct avant de commencer le travail, de connaitre exactement toutes les do nées du probléme, parceque le profil même des lentilles devrait da quelques circonstances être calculé d'aprés ces données.

Quant aux armatures en bronze dans lesquelles les lentilles sont mo

tées il est toujours utile de prévenir d'avance le constructeur lorsque le phare doit avoir une grande hauteur parceque dans ce cas les formes de ces armatures doivent recevoir certaines modifications toujours difficiles et dispendieuses à éxécuter après coup.

III. Il est extrêmement aisé de dresser d'avance des tables indiquant au constructeur l'inclinaison à assigner aux lentilles suivant la hauteur du phare au-dessus du niveau de la mer. Des tables de ce genre existent déjà en France, et il suffit de donner au constructeur la hauteur du phare pour qu'il sache immédiatement s'il y a lieu ou non d'incliner les lentilles et de combien il faut les incliner.

Quant à l'angle de l'horizon à éclairer il suffit d'indiquer cet angle en degrés au constructeur pour qu'il sache immédiatement le nombre de lentilles à employer et l'amplitude à donner aux faisceaux lumineaux.

Enfin pour les problémes spéciaux d'éclairage qui pourraient se présenter et exigeraient le calcul de nouveaux profils pour les lentilles, il doit suffire de quelques jours au constructeur pour faire ces calculs et il existe pour cela des formules d'un usage aussi aisé que celui des tables.

IV. Je n'ai pas eu connaissance qu'on ait eu occasion en France d'assigner aux constructeurs des délais quelconques pour des calculs de ce genre.

En France les ingénieurs des phares, faisant des commandes, préparent d'habitude tous les calculs et arrêtent eux-mêmes les dispositions des appareils, le constructeur n'a à cet égard qu'à se conformer strictement à l'ordre qu'il recoit et aux instructions qui lui sont données pour l'inventeur.

Paris, *le* 20 *Juillet*, 1860.

Monsieur: Nous avons l'honneur de vous accuser reception des listes de demandes touchant les phares que vous nous avez envoyées il y a quelque temps. Nous regrettons qu'une longue absence de M. L. Sautter nous ait empêchés d'y répondre plus tôt.

Sur plusieurs de ces questions, tout ce que nous pourrions dire à la commission est déjâ parfaitement connu d'elle, soit pour avoir été imprimé dans des ouvrages spéciaux tels vue ceux publiés par MM. Thomas et Allan Stevenson, par le Gouvernement Espagnol, &c., soit pour être de plus longtemps pratiqué en Angleterre ou dans d'autres pays. Nous pensons toutefois que la commission trouvera quelques renseignemens nouveaux sur ce sujet dans la "Notice sur les Phares lenticulaires," que nous avons fait imprimer l'année dernière, et dont nous vous prions d'accepter un exemplaire.

Nous nous bornerous à inscrire en face de chaque question, la page de la notice qui referme la réponse, ajoutant, pour quelques unes d'entre elles les observations que nous ont suggerées notre expérience personnelle.

Agreéz, Pc.

L. SAUTTER & Ce.

Au Secretaire de la Commission Royale des Phares, &c.,
7, *Milbank street*, *London*.

I. L. Sautter & Ce., 37 Avenue Montaigne, Paris.

IV. *Voir* Notice sur les Phares, pages 13, 14, 15, et les planches *à* suite.

Dans notre opinion l'apparence de phare dite *à feu fixe varié par de* *éclats* peut donner lieu à des méprises, et il vaut mieux autant que possible s'en dispenser. Nous pensons toutefois que dans les phares à éclat une petite portion de la lumiére doit être conservée sans forme de fe fixe, de maniére que les éclipses ne soient jamais totales.

V. *Voir* Notice sur les Phares, pages 13, 14, 15, et les planches à l suite.

VI. Le systême lenticulaire est sans aucun doute applicable aux fe flottans, (*voir* planche 42 de notre ouvrage.) Nous construisons en moment trois appareils de ce genre pour un gouvernement étranger.

VII. *b.* Quant à la qualité du verre, il faut se préoccuper de sa bla cheur et de sa pureté, mais plus encore de son *inaltérabilité.* Le pl souvent les verres *très blancs* ne le sont qu'à la condition d'être *très te dres*, c'est à dire, de perdre promptement leur poli et leur transparen à l'air de mer. Plus le verre contient de silice, meilleur il est.

d. *Voir* notre Notice, pages 22 et 23.

VIII. Non.

IX. A nos yeux la coloration rouge doit être la seule employée. L verre rouge qui doit être préféré est celui connu en cristallerie sous nom de *doublé à l'or*, parceque c'est le seul qui colore la lumière sans absorber une grande portion, comme tous les autres. Ce verre eta fort cher, et ne pouvant être obtenu en grandes feuilles, la meilleu manière de l'employer est d'entourer la cheminée de cristal blanc, d'u manchon en verre coloré comme il a été dit plus haut. Ce moyen e preférable à l'emploi d'une cheminée en verre de couleur, parceque celle-ci se brise, le phare devient blanc, ce qui est un grave inconvénien

X. *a.* Le rouge.

XIII. *Voir* pages 15, 16, et 17, de la Notice a les planches à la suite.

Nous recommandons particulièrement pour les appareils de quatrièm ordre le systême de rotation sur pivot (planches 31, 32, &c.,) qui donné d'excellens résultats.

Pour les *lampes* nous recommandons beaucoup l'emploi des lampes reservoir supérieur placé tout en haut de l'appareil, avec écoulemen d'huile règlé par une soupape conique. Le maniement de ces lamp est rendu très commode par l'addition d'une pompe servant à remont l'huile dans le réservoir supérieur. Nous en avons construit de cet espèce qui fonctionnaient parfaitement.

CIRCULAR II.

I. *a.* Ce renseignement est indispensable dans le cas où la hauteur d phare est telle qu'il faille donner aux rayons une direction plongeant parcequ'il en traine des modifications dans la construction de l'appare

b. Ce renseignement est necéssaire également parceque dans l'arc q ne doit pas être éclairé, l'optique est remplacé par des réflecteurs.

II. Autant possible ces renseignement doivant être donnés au fabrica en même temps que la commande. Cependant pour le premier ce n'e pas indispensable, il suffit qu'il l'aie au moment ou il fait le monta dans l'atelier.

III. Ces données existent, il est en tout cas facile au constructeur d les calcular, et c'est généralement lui que ce soin regarde.

* * * * * -

1 Hanover Chambers, Buckingham Street,
Adelphi, July 23, 1860.

Sir: In drawing the attention of the Royal Commissioners on Light-houses, &c., to the "Universal Lime Light Company's Oxyhydrogen Lime Light," which they did the company the honor to inspect at their chambers in Adam street, Adelphi, I beg to observe that the adaptation of the lime light to the purpose of coast lighting is one of the primary objects which successive improvers of that system have had in view, as being one of the most important uses to which it could be applied.

Although many attempts have been made from time to time to obtain from this system a uniform and continuous light for a lengthened period, they have from the early attempts of Drummond to the present time failed to realize such a practical result.

The Universal Lime Light Company have, however, been the means of successfully introducing this light in such an improved form that it has been rendered steady and continuous for any desired period of time.

The eminently successful application of it to the South Landing Stage at Liverpool, during a period of two months, and likewise at the New Westminster bridge during a somewhat longer period, have resulted in such an amount of experience, not only in the manipulation of the light, but likewise in the production of gases employed, (viz., oxygen and hydrogen,) which can now be procured at a cost little if it all exceeding that of ordinary coal gas. The probationary experience has likewise shown the probability of a still further reduction in the cost of the elements of the light, which, from its high illuminating power, will place it in such competition with coal gas, that its illuminating value for equal cost will be at least fifty times greater; its peculiar brilliancy, penetrative power, and high intensity conducing to this end.

In addition to the demonstrations already alluded to, the public will shortly have an opportunity of forming a judgment on its value for the important purpose of light-house illumination, as the "Universal Lime Light Company" have been directed by the Elder Brethren of the Trinity House to place their light in the South Foreland light-house, to commence on the 1st of October ensuing.*

Other large and important applications of the lime light are now under negotiation, so that its introduction as a useful, economical, and permanant light may be considered as no longer a problematical or doubtful question in the science of artificial light.

With regard to its adaptation to buoys and beacons afloat, the company are prepared to apply their light to such objects for a period of several consecutive days, in situations where there exist no facilities for daily communication.

I have, &c.,
AMHT. H. RENTON, C. E.

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*Universal Lime Light Company, Limited,
(Engineer's Department,) 36a Belvedere Road,
London, December 3, 1860.

Sir: The looking over the proof of my evidence respecting the lime light, I have erased the date of exhibition at the South Foreland light-house. It has been prolonged by circumstances over which the above company have no control, but which will only cause a short delay in its completion, as the apparatus is in a very forward state, and part in progress of erection at the South Foreland.

I have, &c.,
AMHT. H. RENTON.

J. F. Campbell, Esq.

NOTE.—This letter was accompanied by the following answers to the questions of the Commissioners, and by a pamphlet containing observations on the lime light:

I. Amherst Hawker Renton, C. E., 1 Hanover Chambers, Buckingham street, Adelphi, Engineer to the Universal Lime Light Company, (Limited.)

II. Yes; I consider the oxyhydrogen lime light better adapted for the production of light for light-houses and floating-lights than other known methods of lighting in general use.

III. Yes; the improvements made in the above light since the time of Lieutenant Drummond, and the experience in its use, render the contingency named a very remote possibility.

IV. Reflectors are calculated to show the greatest possible quantity of light produced from any source or method of light; but it is questionable whether a combination of the catoptric and dioptric systems may not unite the peculiar excellencies of both, and produce a more perfect instrument than either separately.

X. Red, for lights of extensive range; but the loss of light by absorption is very considerable, and sufficient to discourage the use of that mode of distinguishing lights where it can be avoided. Other colors, green and blue, are sometimes used but with trifling effect.

XIV. I consider the method of construction proposed by Mr. G. Herbert as best suited for floating lights, embracing the desiderata here enumerated. These light-vessels are of a circular form, and moored at or near the centre of gravity.

XV. *a.* I am of opinion that a modification of Mr. G. Herbert's system of mooring might be advantageously adapted to light-vessels of ordinary construction.

XVI. *a.* I consider Mr. G. Herbert's hollow-bottomed buoys, moored at or near the centre of gravity, to be the best form of construction, and the most conspicuous as sea marks.

b. Ditto, ditto.

c. An adaptation of the oxyhydrogen lime light, which, by the use of compressed gases and a suitable arrangement of the lime wick, may be made available for two or three weeks' supply, in situations where access can only be occasionally obtained.

* * * * * * *

I. Sir David Brewster, F. R. S., Principal of the University of Edinburgh.

II. I consider gas to be in every respect superior to oil, and gas with oxygen as superior to either, as suggested by me in the Edinburgh Review in 1833. I have given reasons for these opinions in the Edinburgh Review, 1833, vol. lvii., p. 189 and 192, and Edinburgh Transcript, vol. xi., p. 69. For new and cheap methods of producing oxygen, see Comptes Rendus, 26th November, 1860, p. 822, by M. M. Sainte Claire Deville and H. Debray.

III. There is no danger which cannot be removed by proper precautions, and I am of opinion that gas may be safely substituted for oil.

IV. I consider polyzonal lenses, or rather lenses in which the zones are composed of separate pieces, as superior to reflectors, whether of metal or reflecting prisms. The want of homogeneity in glass, when in large pieces or entire zones, makes the lenses imperfect. A zone composed of a number of pieces must be superior to the finest entire zone that can be made. I consider flint glass to be, for many reasons, superior to plate or crown glass.

V. I consider the *Whole Light Apparatus*, or holophote,) as described by me in 1812 in the Edinburgh *Encyclopædia* Art. BURNING INSTRUMENTS, and in 1827, in the Edinburgh Transcript, vol. xi., p. 58, consisting of two polyzonal lenses, with smaller lenses and lateral reflectors, and a spherical mirror in whose focus the light is placed, as affording the best means of illumination in light-houses. If the mirrors are plated with silver by M. Foucault's method, their reflecting powers will be great, and their distribution of the incident light superior to what is obtained by reflecting prisms. I am of opinion that a spherical mirror, composed of flint glass prisms, is greatly inferior to one made by M. Foucault's process. Every ray passes through a thickness of glass equal to the diagonal of the prism, and the slightest error in the angles of the prism will occasion an enormous deviation in the reflected ray from its proper direction.

VIII. Colored fluids may be advantageously used.

IX. *b*. Colored chimneys are very bad. The light should fall perpendicularly upon the colored medium, whether solid or fluid. That is, the colored medium should be bounded by spherical surfaces, of which the light is the centre.

X. *a*. This is not a matter of opinion. It should be determined experimentally both for solids and fluids.

b. This depends upon the nature of the fog. Red light would be best in some fogs, and white light in others, supposing the light to be equal in intensity. A white beam of light deprived of all its colors but red, by absorbtion, will not be so serviceable as the white beam itself.

ON THE EXHIBITION OF OCCASIONAL LIGHTS.

Assuming that a dioptric apparatus, illuminated by oil or gas, is sufficient for any light-house in ordinary states of the weather, it is desirable that in fogs an occasional light should be introduced, in order to increase the distance at which it can be seen.

The introduced light may be a Drummond light, or an electrical one, or one of oil or gas rendered more intense by oxygen, or even one of oil or gas alone; and it cannot be doubted that if the range of the light should be extended a few furlongs, or even a few hundred yards, serious disasters might be prevented

The mode of introducing occasional lights has been *shown* but not described in my paper on light-houses.* Two methods of doing this are shown. In the first method the additional light is made to pass through the lamp or gas flame by the refraction of the lens, so that it is introduced into the principal beam as if it radiated from the flame.

But as the additional light thus employed is only the portion of it, intercepted by the lens, the figure shows another mode by which the *whole light* is introduced into the principal beam. This is effected by an ellipsoidal mirror. The same effect may be produced by means of a small holophotal apparatus of lenses and mirrors, which, in place of producing a parallel beam, produces one which converges.

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*Edin. Trans., vol. xi., 1827.

Although the two first of these methods are distinctly shown, yet they are not described in the paper, in consequence of the note describing them having been lost by the printer, and the omission not perceived by the author of the paper; but to any person acquainted with optic the figure requires no description.

These methods are applicable to all lights that are either revolving o employed to illuminate only a portion of the horizon. No addition light can be introduced into fixed lights which illuminate the who horizon, otherwise than by removing the ordinary light, and subst tuting a stronger one in its place, or by increasing the intensity of t ordinary light by oxygen gas.

ON FIXED LIGHTS WITH MANY FLAMES.

In fixed lights where a single flame is placed in the focus of the dio tric apparatus, we are limited to a flame of oil or of gas of a certain si

In order to get rid of this limitation and to obtain a more powerf light, I propose to construct the dioptric apparatus so that its focus not a point but a circle or ring, and in this circle or ring I would pla a number of lamps or gas flames, which would produce a light of gre intensity. The refracted beam would, of course, consist of a combin tion of parallel and converging beams, subsequently diverging, but n withstanding this convergency, a very brilliant light would be obtaine especially with gas flames.

The additional expense occasioned by additional flames will not grudged by those who know the value of the life and property whi are risked at sea.

ON FIXED LIGHTS WITH ONE FLAME.

In fixed lights with one flame in the focus of a cylindrical belt refractors there is no refraction in a horizontal plane, and consequent no condensation of light in that plane. This is unavoidable if an u form belt of light is necessary, and if the apparatus is absolutely fixe

In order to obtain a brighter light from the same flame, I propose place the lenses in a polyzonal frame, and to illuminate the obscu azimuthal spaces in one of three ways:

1st. By having a flame in the focus of each lens, so that each lens m throw into the obscure azimuths the slightly converging beam which produced from the lamps out of its focus.

2d. By giving an oscillatory motion to the lenses in a horizontal pla when one flame is used.

3d. When a ring of flames is used, to give such a motion to the ri that each flame passes through the common focus of the lenses.

The value of these suggestions can only be ascertained experimenta

ON DISTINGUISHING LIGHTS.

In the use of colors for distinguishing lights, it is of great importan when the color is *red*, to obtain a red which is different to the eye, a *also* different in its composition, from the red produced by the abso tion of a haze or fog. It may be difficult to find a red which shall appear different to the eye, but it is easy to obtain one different in composition. We may obtain a red, for example, which is composed of *red* or *blue* light, and when this is examined by a prism, it will be separated into two distinct portions, a *red* and a *blue*. We may obtain compound colors which the prism will separate into three, four, or more portions of light, and thus give a numerical character to the light.

A numerical character may be obtained also from an analysis of the spectrum produced from lights colored by thin plates.

Or by using polarised light, colored or uncolored, from which many distinctive characters may be obtained.

Or by the analysis of polarised light after passing through thin crystalline plates, such as those of sulphate of lime or mica.

The value of these suggestions can be ascertained only by experiments carefully conducted.

HOW TO OBTAIN COLORS OF ANY CHARACTER OR COMPOSITION FOR DISTINGUISHING LIGHTS.

For catoptric light-houses the colored glass employed must be in large plates covering the mouths of the reflectors, and hence it is impossible to avail ourselves of media of which large plates cannot be obtained.

For lenticular lighthouses much smaller colored plates are required, and we have, therefore, a greater range of media to submit to experiment.

In order to obtain any particular color for distinguishing lights we cannot do it by the superposition of plates of different colors, as that would absorb too much of the incident light; but we may obtain it by placing side by side small areas of colored glasses, colored fluids, colored gelatine, or even colored minerals.

If we require a colored plate for reflectors we can obtain one of any color we choose, or of any composition we choose, by forming a square or circular plate of ten, twenty, or any other number of different pieces, and all the colors which those pieces produce will be mixed together in the general beam projected from the lighthouse.

These pieces of differently colored medea may be cemented on one plate of glass with Canada balsam placed between two plates. Portions of colored fluids might be placed in flattened or spherical bulbs, or even in flattened or cylindrical tubes.

In the lenticular lighthouses the same thing may be done, the different portions of the colored media being combined in a spherical surface, and in this case the colors will be more completely mixed by the refraction of the lens.

The colors of thin plates obtained by M. De La Rue's process might be obtained in sufficiently large portions to be combined either with one another or with portions of differently colored media. When combined with one another these colored plates would give, by the analysis of a prism, which might be placed at the eye end of a telescope, a spectrum divided into 2, 3, 4, 5, 6, or any other number of parts.

I consider the method above described of obtaining any color for Distinguishing Lights as likely to prove of much practical value.

I have had occasion to make various suggestions applicable to the improvement of light-houses in the following works:

1. In a treatise on BURNING INSTRUMENTS, containing the method of building large polyzonal lenses, and a descriptions of *whole light* apparatus, or holophote, for increasing the intensity and size of ehe refracted beams. This treatise was published in 1812 in the *Edinburgh Encyclopœdia*, vol. v., p. 140–143.

2. On the construction of polyzonal lenses and mirrors of great magnitude for lighthouses, and for burning instruments, published in th *Edinburgh Philosophical Journal*, January 1823, vol. viii., p. 160.

3. Account of a New System of Illumination for Light-houses, published in the *Edinburgh Transactions*, vol. xi., p. 33, Edinburgh, 1827.

4. On the British Light-house System, published in the *Edinburgh Review*, vol. lvii., p. 169, October 1833.

5. Review of the Parliamentary Report on Light-houses, published i the *Edinburgh Review*, vol. lxi., p. 221, January 1835.

6. Observations on the Distinguishing Colored Lights of the Bell Roc Light-house, published in the *Edinburgh Review*, vol. lxi., p. 526–533, Jul 1835.

7. Memorial on the New System of Dioptric Lights, addressed to th Right Honorable the Lords Conimissioners of Her Majesty's Treasur 1859.

8. On Lighthouses, Life Boats, and Lightning Conductors, publishe in the *North British Review*, for November 1859, vol. xxxii., p. 492.

9. On the British Light-house System, published in the *North Britis Review* for May 1860.

Various suggestions and descriptions of apparatus, and compariso of lenses and reflectors, &c., applicable to the improvement of Light-houses, were communicated by me to tbe Scottish Light-house Boar between 1825 and 1835, and recorded in their minutes. I have bee refused copies of these documents, on the ground that the clerks wer much occupied; but some of them have been printed in the APPENDI to *the Report and Evidence from the Select Committee of the House of Commons on Light-houses*, August 1834.

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FRANCE.

Memorandum of the documents accompanying the note sent in reply to th questions proposed by the Royal Commission of Light-houses and Buoys o England.

PARIS, *June* 26, 1860.

1. PRINTED WORKS.

1. Description of the light-houses lit on the coasts of France on th 15th of August, 1855.

2. Regulations for "gardiens."

2, 3. Instructions sur le service des phares et des fanaux.

3, 4. Reply to claims made relative to the invention of lenticular apparatus.

4. Detail estimatif du service de l'éclairage.

5. "Cahier des charges" for the supply of colza oil.

6. Agreement made with a van contractor for the transport of (all belonging to) the service.

2. DRAWINGS.

7, 8. Lenticular apparatus of the first order.

9. Lenticular apparatus of the second order.

10. Apparatus of the third order (small pattern) and of the fourth order.

11, 12, 13. Lamp flames of the various orders.

14. Tide signals of the coasts of France.

15. Phares des Héaux de Bréhat.

16. Phares de Calais.

17, 18. Phares des Baleines.

19. Phares de la Canche.

20. Phares de la Grande Ile Sanguinaire en Corse.

21. Phare de Kermorvan.

22. Tower for harbor light.

23. Frame work in wood for directing harbor light.

24. Cast metal lamp stand for harbor light.

25. Light-keeper's house with *fanal,* (small light.)

26. Buoy "en tôle."

REYNAUD,

L'Inspecteur Géneral des Ponts et Chaussées,

Directeur du Service des Phares et Balises.

Notes in reply to the questions proposed by the Royal Commission on the Light-houses and Buoys of England.

I. Administrative organization.

A note was sent on this subject, on the 22d of February, 1858, to Lord Clarence Paget. The undersigned is informed that it has been transmitted to the Royal Commission, and to it he refers.

The following is a translation of that portion of the paper referred to which relates to this subject:

Notes on the organization and the expense of the Light-house and Beacon (Balisage includes buoys and beacons, &c.) Service of France.

ORGANIZATION OF THE SERVICE.

The centralization of the service of light-house and beacons dates from the National Convention. These establishments belonged to local corporations, and a law of the 15th February, 1792, united them amongst the duties assigned to the Ministry of Marine, but charged the Ministry of the Interior with the execution of the works. An imperial decree of the 7th March, 1806, changed this service to the Ministry of the Interior, and afterwards to the administration of roads and bridges; but it pre-

scribed a concerted action between the two offices of the French A miralty and Home Office for establishments to be created, and t disposition gave birth to the Commission des Phares, (Light-hou Commission.) Instituted in 1811, this commission was composed in t beginning of three naval officers, three members of the Institute, a three general inspectors of roads and bridges. The commission h now an extra member, and is composed as follows:

His Excellency the Minister of Agriculture, of Commerce, and Public Works, President, in whose absence the commission is preside over by one of its members. Messieurs Mathieu, retired Rear Admira Director General of Naval Stores, member of the Bureau of Longitude Julien de la Graniere, Rear Admiral; Choppart, Captain; Reibell, Inspector General of Roads and Bridges and Naval Works; Garnier Inspector General of Marine Engineering; Leonor Fresnel, retired Inspector General of Roads and Bridges, former Secretary to the Commission; Begat, Hydrographer-in-Chief to the Admiralty; Mathieu, membe of the Academy of Sciences and of the Bureau of Longitude; Dupèrey member of the Academy of Sciences Leonce Reynaud, Inspector General of Roads and Bridges, Director of the Service of Lights and Buoys and Secretary to the Commission.

The Commission of Light-houses is called on to decide (subject to th approbation of the Minister) on all questions relative to the establishment of light-houses and beacons, &c., in all that relates to maritim interests. To it belongs the organization of the system of lighting th coasts of France, the application of the lenticular apparatus invente by its first secretary, Augustin Fresnel, and the programme of work to be executed for marine beaconage, (buoys, &c.)

The general inspector, secretary of the commission, is charged wit the direction and supervision of the service of lights and beacons, & That direction includes two distinct kinds of business:

First, the establishment of illuminating apparatus and works belon ing thereto, their repairs, and all stores, such as wicks, chimneys glass, &c., which are sent from Paris into the departments.

Second, the execution of all the works of construction of light-hous beacons, buoys, and sea-marks, and the service of keeping up the lig ing and beaconing, (*that is, of marking danger otherwise than by light-house*

The director is assisted in works of the first category by an engine of the French Board of Works, (ponts, &c.,) and four conductors, re dent at Paris.

The other works are included in the duties of the engineers of ma time departments.

In each one of these departments there is an engineer-in-chief, seve ordinary engineers, conductors, and inferior agents of the administ tion. The service of lights and beacons constitutes a part more or le important of the duties entrusted to these agents.

COMMENCEMENT OF WORKS.

When the establishment of a new light (fire) is demanded by marine or by a commercial corporation, or by the engineers of the departme the affair is submitted to the Commissioners of Lights, who exami if there is ground for considering the demand, and, in case the reply affirmative, determine the position, the range, (for distance,) and the character to be assigned to the light. If the documents submitted to the commission do not appear to be sufficient for forming an opinion, the engineers of the department are invited to complete them, and they often institute on the spot a naval commission, chiefly composed of mariners and pilots, which is charged to study the different questions of which the preliminary solution is deemed necessary. The work (report) of this commission, with the opinions prepared by the chief engineer and the prefect of the department, is transmitted to the Commission of Lights, who decide on it, taking into consideration the importance of navigation, the nature of the dangers to be pointed out, and the estimated amount of the expense of the first establishment of the service.

The Inspector General Secretary of the Commission then draws up the programmes of two projects for consideration, the one for the construction of the edifice, the other establishing the illuminating apparatus, and he submits them both for the approbation of the Minister, together with the opinion of the Light Commission.

There is no instance of refusal of approbation by the Minister. The first of these programmes is transmitted to the engineers of the departments, who are directed to draw up a regular and complete plan (project) of the work to be executed, conforming themselves to the conditions imposed on them. This project is subsequently submitted to the examination of the Inspector General, who addresses his report to the Minister. If any part of the project includes nautical questions, the Light-house Commission is again consulted. In the contrary alternative, or after these questions have been decided, the project and the report are submitted to the General Council of Roads and Bridges, which is the assembly competent to decide on all that belongs to the science of constructions. Another simultaneous inquiry takes place, together with the one of which mention has just been made, and has for its object to make sure if the projected constructions (works) are not of a nature to exercise an evil influence on the defences of the country, conferences are set on foot with this object between the civil and military engineers of the locality, and the mixed Commission of Public Works, which sits at Paris, gives on the questions in dispute an opinion on which the Ministers decide.

When the project submitted has been approved, with or without modification, it is sent back into the department to be entered as a decision, in whole or in part, and to be executed under the direction and surveillance of the engineers and their agents. The works, which are of a certain importance, are visited in course of construction by the inspector general.

While the edifice is being constructed, the illuminating apparatus is also being constructed in the workshops of Paris, and is mounted and tested at the establishment of light-houses.

It is sent to its destination as soon as the works are finished, and one of the conductors of the central service is sent to the spot to proceed with its installation and to instruct the keepers. The new light-houses are announced to mariners before they are lighted. The delay to be observed between the announcement and the lighting of the new lights, as well as the degree of publicity to be given, are regulated in each case by the importance of the light and its chance of being confounde with any other. The system of lighting the coast of France is als brought to the knowledge of mariners by a chart of lights and by little book. The editions of this book were formerly renewed each yea but they now succeed each other at longer intervals since the modifications in the lights, which are generally important, have become mor rare.

II. THE EXPENDITURES IN 1858.

The expenditures in 1858 for the service of light-houses and buoy amounts to 1,200,000 francs, and may be divided as follows:

	Francs.
Expense of maintenance and great repairs of coast lights (*phares*) and port lights (*fanaux*,) imprests, experiments, &c.	781,440
New works	218,560
Maintenance of buoys and beacons	110,000
New works	90,000
Total	1,200,000

The allowances of engineers and conductors attached to the light-house service are not included in this amount.

The majority of these officers are entrusted at the same time wit other works emanating from the office of public works, and it would b difficult to estimate that part of their remuneration which may be considered applicable to the service in question.

III. List of light-houses lit on the coasts of France.

There is attached to the present note, (annexed No. 1,) the descripti of the light-houses lit on the coasts of France on the 15th of Augu 1855.

A new edition of this document is now being printed, and a copy w ultimately be transmitted to the Royal Commission.

IV., V., VII., VIII., IX., XIV., XV. Questions relative to the gene principles which govern maritime illumination.

The undersigned believes that he should join these questions so as avoid repetition, and comply more effectually with the wishes of t Commission.

DISTRIBUTION OF LIGHT-HOUSES.

Light-houses (*phares*) were formerly placed at the entrance of por or at the mouths of rivers open to maritime navigation. There are no of these at the present day. These points are habitually distinguish only by lights of secondary importance, and the principal lights a carried elsewhere, to places where they are required to be of more se vice.

It is, in fact, on nearing the coasts that the most formidable dange exist, and, consequently, it is the seaboard above all which it is in portant to indicate to the navigator.

So if a light is established on each one of the capes which proje furthest to sea, or on the little island which forms its prolongation se ward, and if these lights are joined two and two, they will occupy th angles of a polygon circumscribed about all the dangers, and they ind cate the coast from as great a distance as the elevation and power of the illuminating apparatus permit.

Such a relation should also be observed in the range and divergence of the lights that the navigator cannot approach the coast without having at least one light within his view. In other words, the distance which separates two angles of the polygon should be less than twice the range,

Those light-houses which are particularly required to indicate the seaboard, constitute "les phares de grand attérage." These are the lights which require the greatest power—these are the lights of first order.

After having indicated the approach to dangers, it is necessary to give the means of arriving at the destination while avoiding them. This is attained by lighting other lights of less range in the larger or smaller bay which is comprised between two lights of the first order. There are points, such as islands, reefs, sand banks, or capes, of which it may interest the navigator to know the position. There are straight channels which it may be useful to mark out, and the power of the light to be lit in these places ought to vary with the distance at which it may be necessary to observe it, while the lights of the first order ought to send their rays on all the sea horizon which they command. Some of these last lights may concentrate theirs into an angular space, more or less confined.

Finally, the navigator having been thus conducted to the proximity of the port towards which he is directing his course, there remains but a feeble light to be placed at the end of one of the piers to show him the entrance of the channel.

The general principles just stated cannot be applied rigorously. The peculiarities of an extended seaboard are too various to permit the arrangement of its illumination according to an absolute formula.

Thus, beyond the sides of the ideal polygon, of which the lights of the first order occupy the angles, an island may be met with or a sand bank which it is essential to mark, and a light of secondary importance should perform this service.

On the coasts of France, for example, the Seven Isles are beyond the line which joins the first order lights of Héaux de Bréhat and Ile de Bas, and there is placed a light called of the third order.

It is the same in the case of l'Ile Vierge between the lights of l'Ile de Bas and Ouessant. Sometimes, also, the configuration of the coast does not admit of the approach of two lights of the first order to the points where their lights may cross, and the interval which separates them is closed by a secondary light. This is what is done at the lights of Belle Ile and of l'Ile d'Yeu, between which is placed a pile light, and at the lights of Agde and Faraman, between which the light of Aigues-Mortes has been placed.

ORDERS OF LIGHT-HOUSES.

The range adopted for the lights of the first order varies from 20 to 27 miles, according to the character which they exhibit. That of other lights varies between much more extended limits, because the circumstances are more various. It is comprised between 18 and 2 miles. These last lights are divided into several classes and orders, according to their power. The number of these inferior orders has been fixed at three by the French Administration, as shall be explained below.

These lights, if multiplied, might expose navigators to fatal mistakes, if means had not been discovered to vary their appearance in such manner that it was easy to avoid confounding them. This resource was not available when the light of light-houses was produced by the combustion of wood or coal; at all events, the only one which was available consisted in grouping several fires on the same spot. It was certainly very limited and very expensive, but the happy invention of Augustin Fresnel came to increase the power of the apparatus and give the means of diversifying their character as much as may be required.

It is above all for the lights of the first order, and for those which at certain points fulfil with them the duty of great coast lights, that it is of importance to have the appearance very distinct, so that the navigator may be duly informed of his position before approaching the coast, and may rectify the error in his reckoning. It is not necessary, moreover, that each of these lights should have a special character. It is sufficient that the distance preserved between each kind should exceed the error of position which may have been committed under the ordinary circumstances of navigation.

It is doubtless not easy to fix a limit for this error, nevertheless, the Commission des Phares has thought that it might admit that a navigator should not deceive himself as to his real position more than about 85 miles, except in extraordinary cases, and after circumstances which call for the greatest caution at the moment of making the land.

Warned of his approach to the shore by the light which he may have within his view, he should not endeavor to make the port during the night, if there be any doubt in his mind.

Moreover, it is to be observed that the mistake which may take place when only one light is in sight, cannot avoid discovery the moment when either one of the neighboring great sea lights, or one of the secondary lights placed in the same neighborhood, shall appear.

This consideration has even allowed the neglect of the limit just mentioned.

Thus the first-order fixed lights of the Ile de Groix and of the Ile d'Yeu are only distant 72 miles, but the first cannot be seen on the same bearing as the second without at the same time noticing the eclipsing light, with half-minute intervals, of the point of Penmarch, of the light varied by flashes of the Isle of Penfret, or of the eclipsing light with minute intervals of Belle Ile en Mer, and even almost always two of these.

These considerations induced the Commission des Phares, in the programme arranged by it in 1825, on the report of the Admiral de Rossel, to allow only three different characters for the lights of the first order: fixed light, revolving light (of which the obscurations recur at intervals of a minute,) and a light eclipsing every half minute.

A fixed light should always be placed between two eclipsing lights of different intervals.

Nevertheless, experience having proved that navigators do not always take sufficient note of the difference observed between the intervals of the eclipses in the revolving lights of which mention has just been made, and, on the other hand, the lights having been multiplied beyond what was foreseen in 1825, the necessity has been recognized of admitting a larger number of characteristic distinctions.

One of them belongs in some measure to the infancy of the art, and which having been adopted at the end of the last century for one of our most important sea lights, that of Havre, was maintained on that point by the programme of 1825. It consists in placing two fixed lights beside each other, at such a distance that they do not mingle within their range, and show from all points as a well-marked group.

This character has, without doubt, the inconvenience of requiring a double expenditure, but it has the merit of being clearly distinctive.

Moreover, several are found on the coasts of England.

It was adopted in France to point out from the offing the dangerous coast at the approaches to the mouth of the Canche, and to illuminate the coasts of the Gulf of Gascony, in the interval comprised between the light of Cordouan and that of Cape Ferret at the entrance to the basin of Arcachon.

Another character, which had been at first reserved for the lights of the second and third order, has been ultimately applied to lights of the first order. That is, the fixed light varied by flashes succeeding each other every three minutes or four minutes; that is to say, at intervals sufficiently long to prevent the possibility of confounding them with ordinary eclipsing lights. This has been chosen for the lights of Calais and the Ile de Sein, and at Porquerolle, so as to avoid all possible mistake between these lights and those in their neighborhood.

Finally, the coloring of the light has been called in in certain circumstances to determine a distinctive character. It had been rejected in the first instance absolutely, and in fact it presents inconveniences which should lead to its employment only with great reserve.

On the one hand it reduces the intensity of the light in a very great proportion, and, on the other, atmospheric conditions occasion at times accidental coloring, which might give occasion to mistakes as to the color of the light; but it has been admitted, as it will be seen below, that these objections had not always the weight attributed to them, and, yielding to the pressing request of the navigators, the Commission des Phares has admitted red color first for the lights of inferior order, afterwards for the flashes of the lights of the first order. It thought that there could be no serious objection to coloring the flashes of varied lights red, because the flashes are not required to increase the range, but to characterize the nature of the light. Instead of varying by the intensity it varies in some sort by color, and the colored light being placed in contact with the white light preserves its relative value, so as to be distinguishable even in foggy weather.

The red color has been adopted in preference to all others as being the most advantangeous in every way.

This important subject will be referred to again further on. Let it suffice to say at present, that the first order light of Fatouville, at the mouth of the Seine, consists of a white fixed light, varied every three minutes by red flashes, and that the Commission des Phares has lately proposed to replace the existing illuminating apparatus of the light at Biarritts by a light of which the flashes following each other every 20 seconds shall be alternately white and red, and to place on the new light-house which is to indicate the western extremity of the Isle of

Ouessant a light of the same kind, but in which two white flashes alternate with a red flash.

Thus, in the existing state of things, the great sea lights of the first order on the coasts of France exhibit eight different characters, which are the following:

1. Fixed light.
2. Light eclipsing from minute to minute.
3. Lights eclipsing from half minute to half minute.
4. Lights varied by white flashes.
5. Fixed white light varied by red flashes.
6. Eclipsing light, with flashes alternately red and white.
7. Eclipsing light with two white flashes, succeeded by a red flash.
8. Two fixed white lights.

The same characters and others besides are applied to the lights of an inferior order. As it shall be explained in that part of the memorandum which treats of illuminating apparatus, we shall confine ourselves at present to saying that some of these lights are fixed red lights, and others also fixed lights, but alternately red and white.

Resumé.—It may be seen that the laws which govern our marine illumination may be summed up in these terms:

To indicate the approach to the coasts at the greatest possible distance, by lights arranged and diversified in such manner that the navigator may be informed of his position as soon as he sees one of them; then to place amongst them lights of which the range may be regulated according to the distances at which it is important to observe them, and which may direct in all surety to the entrance of the port. And to this may be added the problem has been solved in such a manner that on nearly all the points of our seaboard the mariners prefer to make the land by night rather than by day, because they are better and sooner informed of the position of the points which they ought to recognize, and find for their guidance signals which are more apparent and more precise.

The distribution of lights raises still other questions.

In the first place occurs that of the height which should be assigned to them.

It is easy to judge that this height should be such that the tangent drawn from the focus of the apparatus to the surface of the sea may encounter the eye of the observer at a distance from the foot of the tower exactly equal to the range of which the light is susceptible.

Two elements enter, then, into the calculation necessary to determine the height, and these are, the luminous range of the illuminating apparatus, and the height of the observer above the level of the sea.

If it were desired to calculate the luminous range of apparatus of first order according to the intensity of the focal light, and taking for the law the decrease in proportion to the square of the distances, and for term of comparison the distance at which an apparatus of the fourth order or an ordinary light, such as the burner of a carcel lamp, radiating freely into space, can be seen distinctly, much higher figures would be found than those which are generally admitted. Thus, let the range of a carcel burner be estimated at three nautical miles only, and it will be found, by the method which has just been indicated, that an apparatus such as that of a light of the first order, with eclipses every minute, having an intensity of about 3,500 burners, ought to range 177.48 miles. An apparatus having an intensity of 600 burners should range more than 73 miles.

It has not been possible to prove these figures by experiment, for no one of our lights is placed at a sufficient height, and is not in view from a point sufficiently elevated, to admit of observations at such considerable distances, but some facts come, if not to support these calculations, at least to prove that the actual ranges of lights considerably exceeds that which is assigned to them in the official publications.

The fixed light of Cape Béarn, of which the intensity cannot be estimated at more than 600 burners, is sometimes perceived from the lighthouse of Agde, which is distant about 50 miles. This latter light, of which the intensity is about 3,500 burners, is seen from the former very distinctly in all ordinary conditions of the atmosphere, and has consequently a range beyond 50 miles.

But numerous considerations do not allow such considerable ranges to be reckoned on, and these have led to the reduction of the ranges which may be called theoretic, and to their reduction in a proportion the greater as the order of the light is of a higher order. The reduction is still more marked for the eclipsing lights than for the others.

1st. It is important to consider the opacity of the atmosphere of which the action increases with the distance, and this element cannot be closely appreciated.

2d. A lamp with more than one wick is more liable to vary in intensity than a lamp with one wick only. It requires a certain amount of skill in the keeper, and great vigilance, to ensure its maximum effect during the whole night, from which it follows that it is prudent to reckon all the less on the full power of which the apparatus is capable, the higher the order of the light.

3d. It is also to be remarked that the phenomenon of vision is of physiological order; that all eyes have not the same faculty of perception, and that prudence should induce a stipulation rather for organs inferior to the average power than for those which surpass it. And it is all the more necessary to have regard to this consideration the more navigators have an interest in seeing the light at a great distance.

4th. When the navigator has entered into the zone illuminated by a light of the first order he is better informed of his position than he was before: he knows on which side his looks should be directed to perceive the second-rate light, and the slightest glimmer suffices to fix his attention.

5th. A light which only appears during a small number of seconds is not so well perceived at a like intensity as a permanent light.

6th. Lastly, the intensity of the flashes in an eclipsing light is not the same during the entire continuance of the flash. It attains its maximum in the middle, and one cannot reckon on it in calculating the range, for the luminous appearance would be of too short duration to be usefully observed at that limit.

Such are the considerations which have presided over the settlement of the limits to be assigned to the range of the different illuminating apparatus. The figures which have been adopted have doubtless nothing determined, (the subject did not admit of it,) but they have the merit of having been accepted without dispute, and of being rather under than over the truth in the ordinary conditions of the atmosphere.

The subjoined table gives the luminous range of the principal illuminating apparatus, calculated from the law of decrease, according to the square of the distances, admitting a range of three miles for a carcel lamp radiating freely into space, and admitting the maximum intensity for the different apparatus. It places in their relation the ranges which have been adopted in practice.

Theoretic ranges, deduction for the opacity of the atmosphere made, and practical range of the light.

Apparatus.	Hourly consumption of oil.	Intensity of the apparatus.	Ranges.		Observations.
			Calculated.	Adopted.	
	Grammes.	*Carcel burners.*	*Miles.*	*Miles.*	*Term of comparison.*
CARCEL LAMP	40	1	....	3	....
CATADIOPTRIC APPARATUS:					
4th order. Fixed, of 0*m*. 375	60	14	11. 23	10	....
3d order. Fixed	175	90	28. 46	15	....
2d order. Fixed	500	280	50. 25	18	....
2d order. Eclipses 30″ to 30″	500	1, 200	103. 92	20	....
1st order. Fixed	760	600	73. 47	20	....
1st order. Eclipsing 30″ to 30″	760	1, 900	130. 77	22	....
1st order. Eclipsing from minute to minute	760	3, 500	177. 48	27	....

The luminous ranges being thus limited, the heights to be assigned to the different apparatus above the level of the sea is calculated, making an hypothesis as to the elevation of an observer with respect to the same plane. The known formula is employed:

$$P = \sqrt{\frac{R\,B}{0{\cdot}45}} + \sqrt{\frac{R\,h'}{2.04}}$$

which takes into account the refraction of the atmosphere, and in which—

P indicates the range;

R the radius of the earth at lat. 45° = 6,366,669m.;

h the height of the focal light above the level of the sea;

h^1 the height of the observer's eye above the level of the sea.

It seems that the hypothesis under consideration should be made in the same spirit which presided over the determination of the luminous ranges; that is to say, in such a manner that the effective ranges should be rather over than under the ranges indicated.

A height consequently should be taken as a point of departure, which may be regarded as the lowest at which the eye of the observer placed in a vessel may be found above the sea level; such as, for example, two metres; but one would be thus led to set down figures which would lead to very considerable expenditure on construction, and these expenses would not always have a sufficient motive.

Let us suppose, for example, that a light of the first order, with eclipses from minute to minute, has its base placed at the level of the highest tide. In order that it may be seen at the limit of its range by an observer placed as has just been said, it would be requisite that the focal light should be placed at about 130 metres above the same plane, and would have sufficed to raise it to 100 metres if one were content with a range of 24 miles, so then it is evident that the advantage which may be derived from allowing a small vessel to perceive the light at 27 miles, instead of observing it only at 24, is not sufficiently great to cause the adoption of the increased expenditure which the increased elevation would require, namely, that of 30 metres of a tower which already has an elevation of 100 metres.

It has not even been thought that it is fitting to reach the last elevation.

The elevation of the towers are regulated as well by the power of the apparatus as by the expense of construction, and the navigators are aware that they should raise themselves to a determined height above the level of the sea, if they wish to perceive a light of which the elevation is known to them, up to the limit fixed for the range.

The subjoined table shows the heights which have been given to certain of the light-houses of the coasts of France, of which the base is covered at high tide, or is raised but a small distance above the level of the sea, and places in relation the ranges of these lights, and the altitude to which the eye of an observer should be raised to perceive it at these distances.

Name of light.	Order.	Character.	Range.	Height above the level of the highest tides.		
				Base of tower.	Focus of the apparatus.	Observer's eye.
Héaux de Brehat	1st	Fixed	20	—4.00	45	8
La Hague	do	Fixed	20	1.50	47	7
Dunkerque	do	Eclipsing from minute to minute.	27	1.80	59	27
Baleines	do	Eclipsing from 30″ to 30″	22	0 45	50	11
Penmarch	do	Eclipsing from 30″ to 30″	22	0.04	41	16
Cordouan	do	Eclipsing from minute to minute.	27	—3.00	59	27
Four	2d	Eclipsing from 30″ to 30″	18	—3 20	24	13
Lilier	do	Flashing from 4′ to 4′, preceded and followed by short eclipses.	18	4.00	32	8
Haut-banc du Nord.	3d	Fixed	15	—7.00	22	6
Aigues-Mortes	do	Flashing from 4′ to 4′, preceded and followed by short eclipses.	15	1.00	20	7

Certain of the capes which are marked by lights of the first order are so lofty that they raise a question diametrically opposed to that just referred to. It is a maximum and not a minimum which has to be determined.

Two principal considerations lead one not to exceed certain limits for the height of the base of the tower. In the first place, the highest points of mountains are subject to be clouded; in the second place, the communications with the light-house become difficult, and the cost of transport renders the construction more expensive.

The most elevated light-house on the coast of France is the fixed light of first order of Cap Béar. It is 229 meters above the level of the tides. In clear weather this light is seen at great distances at sea, but it is more frequently masked by the fog than if it had been placed on one of the lower gradients of the cape, at an elevation of about 150 meters; and perhaps it is to be regretted that this plan was not adopted. It had also been proposed to place a light of the first order on Cap Sicié, between Marseilles and Toulon, and this point appears to be very well fitted for the purpose when one glances at the chart; but the Commission des Phares has rejected this proposition, because inquiries have shown that the cape is often clouded in consequence of its elevation.

The most elevated light-houses of the French seaboard are, after the light-house of Cap Béar, those of Fécamp (130 m.,) La Hève (121 m.,) Fatouville (128 m.,) D'Agde (126 m.,) Cap Camarat (130 m.) The light-house of Cap Carbon, in Algeria, has an elevation of 220 m., and it would probably have been more advantageous in all ways to have placed it lower.

It is impossible to state anything on this subject absolutely. It may be necessary to place a light-house on a culminating point, so as to place it in sight of the whole sea horizon, and, moreover, all elevated spots are not equally exposed to be masked by clouds; but it may be stated as a general thesés that there is no real advantage in exceeding a height of 130 m. in all that concerns the really useful range of the lights.

FLOATING LIGHTS.

There has been no question up to the present time of floating lights, and one need not dwell at length on that subject, because this method of illumination is but little used in France.

Lights placed upon buildings are there much preferred, and that preference is founded on the following reasons:

1st. Floating lights raise the illuminating apparatus to but a small elevation (12 to 14 miles) above the level of the sea, and consequently they have but a very limited range.

2d. They do not seem to offer so much assurance of permanence as the others, and when they are moored at points where the sea is at times very heavy.

3d. They require more expenditure on maintenance, and are with difficulty subjected to a sufficiently active surveillance.

They are only employed to point out the sand banks on which it is not thought that they permit the placing of a fixed construction, either by reason of the expense which would be required, or in consequence of the movement of the bank. There are, in fact, but three on the coasts of France. They indicate the moveable bars at the mouth of the Gironde.

LEADING LIGHTS.

A question very interesting for practical application is that of knowing what is the distance to be fixed between two lights which are wanted to point out the direction of a passage.

It is necessary, on the one hand, that the lights should be distinct, up to the distance at which they should be seen, and on the other, that when they do not show at the same height one may not stray from the line for which they serve as beacons to such an extent as to go out of the passage, without observing with certainty that they are not placed in the same vertical line.

The first of these conditions springs from the phenomenon of irradiation of which the action is of physiological order, and varies with individuals. The second belongs to correctness of eye, to the feeling for form, which again is still less susceptible of an accurate estimate.

Experiments have been made on this subject at the Light-house Establishment. They have led to the admission that two white lights of the intensity of those which are given to the phosphores, that is to say, equal to 40 carcel burners, are very distinctly seen when the radii proceeding from the eye of an observer to each one of them make, in horizontal projection, an angle of 4′ 30″, and that it is sufficient when these lights are placed at different elevations that the angle is made 6′, in order that one may judge whether they are or are not placed in the same vertical line. The breadth of a given channel being known, the position of one of the lights being determined, the conclusion is arrived at from the experiment given as to the position to be assigned to the other light. The figures, moreover, which have been given are looked on as the lower limit, and it is of advantage that the lights should be seen at more open angles before the limits of the channel are approached.

VI. Number and pay of light-house keepers:

The number of keepers varies with the importance and position of the light-house.

There are three for the light-houses of the first order, two for the light-houses of second and third order. The lights of the fourth order, or fanaux, have but one single keeper.

In the light-houses which are isolated at sea, there are always three keepers, whatever the order of the light may be, so that the service may never be exposed to interruption, and that leave may be given to the persons employed at regular periods. The light-houses of the first order which are so placed have four keepers.

The keepers are divided into seven classes, of which the salaries are the following:

	Francs
Maitres de phare	1,000
Gardiens de 1re classe	850
Gardiens de 2me classe	775
Gardiens de 3me classe	700
Gardiens de 4me classe	625
Gardiens de 5me classe	550
Gardiens de 6me classe	475

The keepers are provided with lodging, fire, and light. They may obtain rewards, of which the maximum is fixed at a month's allowance.

They have the right to a retiring allowance, and, in consequence, there is a deduction of 5 per cent. on the amount of their allowances.

To this note is annexed the regulations for the keepers on the coasts of France.

VII. and VIII. Replies have been given above to these questions.

IX. Colored lights:

White lights are those which, for a given expenditure of oil, have the added to this note, under the numbers 3 and 4, two little pamphlets which had to be published to rebut certain regretable pretensions, and to reply to certain attacks still more to be regretted.

It is very essential that the keepers should give to the lamp flames all the development prescribed by the instructions. With a view to be very exact on this subject, the administration has caused to be engraved representations of the natural size of the flames of lamps of divers orders.

XIV and XV. Replies have been given above to these questions.

XVI. Mode of ventilating lanterns:

The air is introduced into the lantern by a series of rectangular openings made in the lower sill of the lantern, and which are shut at will. It escapes by a central chimney in all the lanterns, and besides by ventilating chimneys placed at the foot of the cupola under each panel in lanterns of the three first orders;

XVII. Nature of the oil:

The oil employed for the illumination of light-houses is colza oil. Experiments, into the details of which it appears useless to enter, establish that it is the most advantageous of all the common oils, as respects the production of light.

Schist oil, produced by the distillation of bituminous rocks, has been employed for a year in the illumination of certain harbor lights. It has the disadvantage of producing an extremely thick smoke when the flame is not properly managed, but it is cheaper, and has a luminous intensity nearly double for the same consumption. The manner of burning it so as to produce the volume and brilliancy required for lights of the three first orders has not yet been attained.

XVIII. Other methods of producing light:

Several other modes of producing light have been tried, but no one of them has appeared to be of such a nature as to enter into practice. The magneto-electric machine appears to offer a chance of success, and it is at present the object of experiments which are followed out at the "Atelier des Phares." It presents a constant and economical source of electricity, but the problem is not so well solved in what concerns the production of light. The carbons which are found in commerce leave too much to be desired, both as to the duration and the luminous intensity. Certain more favorable results have been already obtained, and are an encouragement to renewed attempts.

XIX. Mode of negotiating for the execution of works and diverse supplies:

The construction of the building of light-houses is the subject of public adjudications which take place on estimates. When works at sea are in contemplation, which are subject to incidents which do not admit of an appreciation of the expenditure to be made, the adjudication only extends to the furnishing of the materials of construction at the port of embarkation. The transport and the placing of these materials are effected at the cost of the administration, under the immediate direction of the engineers.

The agreements are passed from time to time, and are submitted to the approbation of the minister for the furnishing of floating lights, buoys, beacons, illuminating apparatus, and all the small provisions of wicks, glass chimneys, utensils, &c. These last provisions are delivered to the central light-house establishment at Paris, who forward them to the light-houses as they are wanted.

Special agreements have been entered into for furnishing oil at the light-houses.

XX. Reception of supplies:

All the supplies for consumption, except oil, are made at the central light-house establishment, where they are verified by the engineer attached to the central service, who prepares when required a memorandum of the receipt.

Oil is received and verified at the light-houses, according to the provisions of the "Cahier des Charges."

XXI. Renewal of the paint of light-houses and buoys, &c., and the materials employed.

The paint of most of the light-houses is renewed only every two or three years. The floating lights are painted each year. The buoys and beacons are painted every six months. The paint used is white lead or white zinc.

XXII. Manner of coloring:

The system adopted for the coloring of buoys and beacons on the coasts of France has been described in the preliminary observations placed at the head of the description of the light-houses. It need only be added that all the salient angles of docks (musoirs) and all the towers of harbor lights are colored white.

XXIII. Examination of propositions relative to lights and beacons, &c.:

The note sent to Lord Clarence Paget, to which reference has been made, relative to the first question proposed by the Royal Commission, has shown the course followed for the commencement of the works belonging to the establishment of new light-houses and new buoys, and to important modifications to be introduced into existing establishments.

As to all the questions which belong to the improvement of illuminating apparatus, and to the dispositions to be given to them, they are dealt with by the Engineer Director General of the service, and it is in like manner to his examination that all inventions concerning lighting and buoyage are referred. The Minister decides on his recommendations.

XXIV. Meteorological instruments, barometers, thermometers, and a small number of rain gauges, are the only instruments of this kind which are placed at light-houses. The keepers enter their observations on registers, of which it is easy to fancy the composition.

XXV. Tide signals:

The document attached explains the system of tide signals adopted on the coasts of France for indications to be given during the day. The same system can be applied by night by replacing the ball placed at the intersection of the mast and the yard by a red light, and the others by white lights. These night signals are only in use in the port of Havre.

XXVI. Fog signals:

Numerous experiments have been made at the central light-house establishment, for the purpose of discovering what is the best apparatus to employ.

It has resulted from these, that a trumpet properly arranged, or whistles acted on by steam or compressed air, give excellent results;

but the expense which the placing of machines necessitates, have not allowsd the adoption of the system. In the actual state of things, it has been decided to rest content, in the meantime, with a bell, with reflectors of mason work, and set in motion by weights. There is a project of varying the sound, for the purpose of avoiding confusion. The question is still under consideration.

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XXVIII to XXX. Buoys and beacons:

Various forms of buoy are employed on the coasts of France; they resemble more or less those which are in use on the coast of England, and it is not yet perfectly decided which one merits the preference.

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This buoy is executed in sheet iron, (tole,) it weighs about 1,750 kilogrammes, the cast ballast not included. This ballast is disposed so as to be regulated according to the length of the mooring chain. Its maximum weight is 740 kilogrammes. The form of the marks (voyants) vary with each buoy. The mooring chains are of iron, round, of 0.034m. diameter. The moorings are mushrooms in cast metal, of from 600 to 700 kilogrammes for sandy bottoms, and anchors with forked fluke for rocky bottoms. These buoys hold themselves well on the water.

Beacons are executed according to divers systems, according to the local circumstances.

On certain points they consist of simple perches of wood or iron, which are planted on the shoal to be pointed out, and are usually surmounted by a mark (voyant.) This arrangement is economical, but it is but little satisfactory. The beacons are badly seen, and are frequently broken.

Certain of these works consist of pyramids of three or four sides, executed in forged iron, and which are furnished with panels of plank or sheet iron on their upper part. This construction is more expensive, but it is durable and very visible.

In conclusion, there are also to be found towers of masonry, executed not of hewn stone as formerly, but of small materials, of which the transport and disembarkation are easy. These stones are built in with a mortar of Portland cement in the interior of the work, and with a rapidly-setting cement, such as the Parker Medina, on the outer courses. It is the rule that the towers should have an elevation of at least four meters above the level of the highest tides, and that their diameter should be the half of their height, and never be less than three meters.

Such is the information which the undersigned thinks of a kind to meet the wishes of the Royal Commission. He regrets not to have been able to enter into more extensive details, but the Royal Commission will find him very anxious to reply to all the new demands which it will do him the honor to address to him.

REYNAUD.

PARIS, the 26th of *June*, 1860.

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SPAIN.

Answers to the questions put by the Royal Light-house Commissioners appointed in England.

MADRID, *February* 1, 1860.

I. The system of administration which is in force in Spain with respect to light-houses, buoys, and beacons, is identically the same as that of France. They form part of the especial branch of public works, and depend, like the latter, on a general board of direction established at the Department of Public Works. There is also attached to the said direction a permanent commission, composed of engineers of superior rank, of the corps of roads, canals, and ports, and of chiefs of the same rank, belonging to the Royal Navy, who are always consulted, when it is intended to modify or vary the general plan of lighting, or to establish some new light, as also upon any system of beacons, in which cases they determine the site or place in which they are to be situated, their height above the level of the sea, and the distinctive character and appearance which they must possess, in order to avoid their being confounded one with another.

In all else, the construction and establishment of this class of works, as well as their preservation, appertain to the engineers of the said corps, who are distributed in the provinces; and they and the works are usually visited at stated periods by their immediate superiors, who are other engineers, with the title of inspectors, and who form the superior class of the corps. The duties, therefore, and powers of the said individuals, their responsibility to each other and to the Government, are entirely analogous to those which are established in France.

With regard, however, to the lighting and beacons of the coasts of Spain, the captains of ports are under the necessity of watching their effects and of communicating the observations they may make to the engineers, and, also, if they think it necessary, to the chiefs of the marine department, so that their recommendations may be so effective as to secure the adoption of every improvement which may be necessary.

II. In the 99th page of the plan of lighting, the general law is inserted, in virtue of which a special tax is collected, the product of which is to be applied to the service of lighting the coasts; but the revenue thus derived enters at once into the public treasury, and the amount of the liabilities of each year, whether for new works, or for materials for the maintenance, lighting, and service in general, are met by drafts on the credits opened by the budget of the State.

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XII. The makers are Mr. Sautter and Mr. Lepaute, established in Paris.

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XVI. For the ventilation of the lanterns, it has been found that the arrangements adopted by the French builders answer sufficiently well.

XVII. The best olive oil, which comes from Andalusia and all the other provinces on the coasts of the Mediterranean and the Balearic Islands, is used for lighting.

XVIII. No other means are used, nor has there been any attempt to employ other means of lighting.

XIX. As the organization of the general maritime system of lighting is of a comparatively recent date, no contracts have been made at public auction, excepting for the building of the edifices, and even some of them have been constructed by the administration, for want of bidders. The furnishing the oil has also been contracted for for the greater number of light-houses, but, so far, (excepting in a few cases,) for each one separately. It is possible that in course of time a greater number of light-houses may be included in one contract, and that the supplying collectively the greatest possible number of establishments may be productive of economical results. The lantern apparatus and the principal supply of objects not made in Spain, have been contracted for with Parisian makers.

XX. In order to be certain of the quality of the oil, it is ascertained whether it fulfils the conditions contracted for in the deed of contract. The said conditions and the proofs to which the oil is submitted are mentioned in the appendix to the instructions for light-houses at the end of the plan of lighting.

XXI. The light-houses have been painted whenever their proper maintenance and appearance required it; but owing to the recent formation of this branch of the public service, there has not been sufficient time to fix the periods at which the paint ought to be renewed.

The same remark applies to the buoys and beacons.

XXII. For the above reason, an exact answer cannot be given to this question.

XXIII. The branch of the service relating to the light-houses and beacons of the coasts of Spain being in course of organization, it can only be said, in answer to this question, that, according to the experience already obtained, all the regulations of the plan adopted fulfil their object, and that, nevertheless, endeavors are being made to study any improvement which may perfect it in any of its parts; so much so, that to make sure of the result, care is taken to ascertain what is the opinion of the corporations and persons most interested and competent in the matter, and, finally, the proper suggestions are made by the commission mentioned in No. I.

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NOTE—Maritime lighting is recent in Spain, and the system of beacons has not yet begun to be in force, as buoys are only now in course of construction. For both these reasons, some of the questions cannot be answered as much in detail as is wished; but this will cease to be the case before long, as complete statistical returns are being prepared, which will show the annual cost of all the articles in each light-house, and the expenses and observations to which the system of beacons shall have given rise. A report will be published every year on the state of public works, similar to the accompanying one, in which will appear all the suggestions which the service to which it refers may offer; and by this means the British Commission will be enabled to keep themselves informed as to all that passes in Spain in the department of public works.

DENMARK.

LIGHTS, BUOYS, (FLOATING MARKS,) AND BEACONS.)

Answers to queries relative to Lights, Buoys, and Beacons.

I. The light and buoy service is placed under the superintendence of the Ministry of Marine, who decides directly upon all concerns relative to the personnel, its admission and dimission, discipline, &c.; decides upon the foundation and placing of new light establishments and sea-marks, upon alterations in the old ones; further, upon all matters that may subserve the developing of the light and buoy system.

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II. The necessary funds for the light and buoy service are obtained by appropriation of the legislature, "the Council of the Realm" (Rigsraadet,") and are always voted for biennium of finances.

The expenditure consists of two principal categories, viz., ordinary and extraordinary expenses. The first embrace the sums annually expended on wages of the personnel, on the maintenance of the materials approved of, &c.; the latter are the sums appropriated to the motivated memorial of the ministry for the erection of new lights, for the augmentation of the sea-mark material, and upon the whole for works of rather great extension.

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IV. The establishment of a light being resolved, it is to be decided upon whether the light can be shown from the shore or absolutely must be shown from a vessel; and it is evident that we, the territorial circumstances allowing of the foundation of a tower, and, for the rest, the option being with us, rather choose the first alternative, regarding the relative greater cost of the annual maintenance of a light-vessel. Any general principle, therefore, cannot be put down, yet we endeavor to pack the lights as outwardly as possible on the points that are to be passed.

V. The lights are divided into government and communal lights. To the first, the main part, are reckoned all the "sea lights;" to the latter, a few small lights, only leading-marks at the entrance to roadsteads or harbors. This sort of lights, as far as they are thought proper to be mentioned in the list of the lights of the monarchy, is therein classified as "harbor lights." They are maintained at the cost of the respective communities.

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The light and buoy inspectors being naval officers, their pay as such, and corresponding allowances when travelling.

The personnel of lower officials is distributed as follows: For a light of the first order are allowed three for a light; of the second, third, fourth, or fifth order, two officials; and for a light of the sixth order, one official. The localities of a few lights established on very isolated points on uninhabited islands, where it is necessary to keep boats, compel, however, to deviate from this arrangement, and to augment the regulated number by 1 to 2 individuals.

Commissioned are: For the lights of the first, second, and third order, two light-keepers (one light-master and one assistant;) for the lights of the fourth or fifth order, one light-master; the official by the light of the sixth order is named "attendant," the small and frequently quite plain apparatus regularly not claiming a steady watch in the burning time as necessary, if but a regular attendance be kept, and where thus the nature of the service not forbids the keepers to unite another occupation as principal livelihood with the light service; hence this sort of officials is sought for among the populace in the vicinity of such lights, generally they are post or custom officials.

To the class of servants are reckoned the third official by the lights of the first order, and the subalterns by the lights of the fourth and fifth order.

The commissioned officials in the light-vessels are, one master and one mate.

VII. Head lights, or lights of the first order, are considered necessary only on such points of the coast of the country where they have to lead in from the open sea, lights of the second and third or lower order being perfectly sufficient for the leading or warning of the navigation in the fairways that surround the islands.

VIII. Regarding the lighting power of the light apparatus, are in use—*a*, fixed lights, *b*, revolving lights, and *c*, fixed lights with flashes.

IX. See the list of lights, by which it also will appear that the colored lights are either red or green, the red light always being preferred to the green, if the circumstances permit of any choice.

X. The lighting power of a light is defined according to the speciality of the fairway that is to be illuminated. To make the light more powerful than necessary is, from a state economical point of view, considered as wrong as it in nautical respect could be pernicious. As regards the mechanical arrangement of the light apparatus, the species that gives to the light the greatest intensity is preferred, viz., "fixed light with flashes," if the option for the rest be free and no mistaking it for other lights in the vicinity to apprehend.

The colored light is, indeed, one distinction more besides the three above mentioned to define the character of the lights, the use of colored light, however, weakening the lighting power, it is only applied to a few small lights where necessary, and where these are not to be reckoned in the category of sea lights.

Such are the principal rules which, as mentioned in the execution, are subject to different influences; hence, they cannot be considered to involve any general principle.

XI. The lights have either lens or reflecting apparatus, as noted in the annexed list. Generally, the lens apparatus are preferred, whose advantages are too often demonstrated and too universally acknowledged as to need being exposed. The lens apparatus will, therefore, by-and-by, be introduced in all Danish light establishments, however, with the following three exceptions:

1. Fixed lights, whose illuminating angle is less than 180°.

2. Revolving lights of lower order than the third, such not being answerable, or of the third order with very short, 10 seconds, or with very long, 2 minutes flashes.

3. Harbor lights, where the use of reflecting apparatus generally is more convenient as well in reference to the application as to the attendance.

XII. All the lens apparatus in use in the Danish light system are on the Fresnel principle, executed by the mechanician, Lepaute, in Paris, always furnished with the most recent improvements. As regards the wished-for drawings, refer to the mechanician himself.

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XIV. In the selection of the lighting apparatus, we seek to obtain the greatest possible difference in the lighting effect between contiguous lights, principally by alternating with fixed lights, revolving lights, and

ere necessary, with fixed lights with flashes. For further distinction,
also used different divisions of time for the apparition of flashes,
ying from ten seconds to two minutes. Colored lights, as mentioned
X, are avoided, namely, as regards the principal fairways.

V. As regards the height of the light of the light-houses, it is adopted
same in new lights, not to exceed 180 feet, Danish measure.

VI. The ventilation of the lanterns is regulated by three to five
ss ventilators, provided in the parapet wall beneath the lantern, and
a turn-cap on the summit of the cowl of the lantern. The products
the combustion are through copper pipes furnished with dampers
ried from the lamps up into a great vertical copper tube, which
ns in the turn-cap mentioned above, and by openings in sides, can
e up any vitiated air in the lantern room. The smoke from the
ve is by other copper pipes carried through the cowl, and to the end
the tube a turn-cap is fitted. In order to prevent the lantern-panes
n being coated with dew and ice during the winter, the lanterns in
greater light-houses are provided with double plate-glass panes, be-
en which chlorcalcium is put in order to attract the moisture that
ght force its way in between the panes.

VII, XVIII. For the light-flames is, with very few exceptions, no
er illuminating stuff in use than best refined rape-seed oil.

IX. *a.* All the light-house buildings, light-vessels, and all materials
onging to the navy yard, and the maintenance thereof is provided
the same.

he light-vessels are built and equipped at the navy yard.

he buildings are erected by contract with mechanics throughout the
ntry, and the materials are principally delivered by public tenders.

. All apparatus, the lens apparatus and reflectors for the light-ves-
s excepted, are made in the mechanical workshops in the country,
d so are the lanterns, which are made of bronze with transverse
ming and double plate-glass panes, and covered with a double cop-
r cowl.

The lens apparatus are furnished by the manufactory of Lepaute, in
ris, and the silvered parabolic mirrors for the light-vessels by the
nufactory of Wilkins, in London.

. All the light-buildings are painted and maintained either by agree-
nts to different amounts made yearly with mechanics in the vicinity,
by contracts for several years to definite yearly amounts. This latter
de is found answerable particularly for isolated establishments.

d. All materials for the light establishments are provided either by
blic tenders or by contracts, are stored at the navy yard, and are sent
twice a year to the light establishments.

. A few lights are attended to and maintained by contract yearly.

These contracts are successively rescinded, a direct administration
ng considered more answerable.

X. All materials for the lights are, before being put in store, tested
a committee, of which the engineer is a member. Each lot of oil is
ted by burning in test-lamps for the special purpose, and if the lamps
n free for 20 hours, without much charring of the wick, the oil for
rest being limpid, having a fresh odor, and being free from acid,
ich is tested by lacmus paper, it is accepted. The whole stock of
is consumed within nine months after the testing. The wicks and

glass chimneys are tested by comparing the same to pattern checked for the purpose. The woof in the wicks is made of untwined silk and the warping of brown cotton.

XXI, XXII. All light establishments, light-ships, beacons, and floating marks are subject to inspection once a year. The brick towers, where used as day-marks, are kept whitewashed as far as thought necessary for the furtherance of the purpose, otherwise the natural stone color is preserved; all the iron towers are painted white with red upper parts (caps;) all the light-vessels have the outer side of the hull painted red, with a white cross, in the horizontal part of which the name of the station is set in black Roman letters. The beacons are generally painted black or tarred, and the floating marks, namely, the buoys, are painted with such colors as are regarded the most agreeable to the purpose, the guidance of mariners.

XXIII. In the year 1854, a plan to an adequate coherent illumination of the fairways of the Monarchy had been elaborated by a commission appointed for the purpose. This plan has been approved of by the Ministry, and endeavors are continually made for carrying it into effect.

The plan gives for each singular establishment the order and class o the light apparatus, the character or lighting effect of the light, th height of the light-flame over the level of the sea, and the range of th lighting. As to future experiments, with new illuminating stuffs an other essential improvements and changes in the method at present i general use, we cede to the greater nations to try such, adopting bu the results which have proved practicable and answerable for th development of the light system, either through the initiative of th light-engineer, propositions from committees O. T. L., or by immediat ministerial resolution.

As regards the development of the buoy system, the buoy inspecto have the initiative relative to the improvement of the material, an concerning propositions to the placing of new sea-marks, such are generally made by the officers of the navy, who generally are detatched t surveys in our waters; none of the mentioned arrangements, howeve can be put in operation without authorization of the Ministry.

XXIV. The observations of the barometer, of the psychrometer, of t appearance of the air, the direction and force of the wind, are made the Danish light-houses at 7 and 10 a. m., at noon, and at 2, 4, and p. m. The quantity of rainwater fallen is emptied at 9 a. m.

XXV. Signals indicating to passing ships the state of the tide are n made from any point on the coast of the Monarchy, nor from the ligh ships, as notice for the entrance into a few friths on the western coas and for the post steamers in Korsör harbor, a few common optical tel graphical means are put up, which, however, are of no interest for th navigation in general.

XXVI. Neither are fog-signals given from the shore. The light-shi masters are, however, instructed to let a gong be struck in such cases five minutes at a time, with an interval of five minutes.

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CLOSER EXPLANATIONS.

Those floating marks mentioned in the list under the name of "conical buoys" (coniske Tönder) all together deriving from a former buoying system, are by and by, as they are drawn into condemnation for great age, to be replaced by pointed or bottled-shaped buoys, which possess greater supporting power and work less in the moorings.

Also the supporting means of the stakes of the perch buoys, in as far as they are conical buoys, are by and by to be changed for bottle-shaped ones.

Those floating marks set apart as belonging to the ancient store of materials, the actual buoying system consists, a few marks of common barrel-form omitted, partly of Peacock's buoys, pointed and bottle-shaped buoys, partly of summer and winter perch buoys, or, as they also called, cask buoys (Töndevagern) and log or ice perch buoys.

The Peacock buoys and the elements and appearance of the perch buoys are briefly touched upon in the "general review." The buoys are ordinarily made of oaken staves, put together in the customary manner by strong iron hoops, kept at their place by small plate irons riveted to the staves, and by iron bands, which lengthways of the buoy cross the hoops.

The buoys are of different sizes, suited to the localities in the fairways where they are employed, the length of the nun buoys (Spidsœnderne) thus being 13, 9, 6, and 4 feet, with a diameter over the middle of 5½, 4½, 3¼, and 2 feet; the length of the bottle-shaped buoys is 9, 7, 5, and 4 feet, with a diameter at the bottom of respective 4½, 3¾, 3½, and 2½ feet.

The buoys for winter use of both sorts differ from those prepared for summer use, but therein that the staves are lengthways over the whole, coated with band iron to the very points, which are coated with thin iron plates, to prevent the ice from cutting the wood and breaking the staves.

Besides, through the different size and form, the buoys are distinguished through different color, and where the circumstances make it desirable for further guidance for the navigation, also through one or another distinction painted on the buoy, or through one of those top-marks, for the perch buoys mentioned in the "general review."

From the above given dimensions and shapes differ, however, a little the nun buoys, made of iron plates, which, altogether, are 12¾ feet long, with a diameter of towards 4 feet on the broadest.

These iron buoys and all the 13-feet nun buoys are floating in an upright position; the stability necessary for this purpose is provided through a fixed bottom applied at a certain height from the foot-end. thus furnishing them with a compartment into which the water may run through holes managed in the lower end of the buoy.

The attendance of the floating marks, as far at the circumstances allow, is placed under the local control of the coasters in the neighborhood, who keep boats. against an annual reward.

In the eastern district, where the boats ordinarily are small and at some places unfit for the managing of the larger and more ponderous sea-marks, together with their mooring apparatus, the perch buoys, as more transportable. are used for marking.

In the western district, where boats well fitted for the attendance of the larger marks are not wanting, and where, besides, it is in the interest of the navigation that both sides of the principal fairways, cut deep in between the islands and the sands, are distinguished through high showing marks, distinguishable at a long distance in the hollow - a setting in under a sea storm; in this district the perch buoys are not employed, but in a few small fairways, not much used, and in the inner part of the by-passages, where sea and current are less strong than the outer passages.

Where in the list it is not noted to the respective marks, that they are taken in during the winter or changed for special winter marks, they still lie out all the year round, and are only taken in for inspection, during which they are replaced by spare marks. The use of the 5 and 6-feet iron-tipped winter buoys, formerly employed only in the southern part of the western district, for replacing the more expensive 7 by 9 feet buoys, is, however, of late, from economical points of view, extended for replacing also of the rest of the 7 and 9 feet buoys in the district, denoting points that are kept marked during the winter, with the exception only of the few buoys of the often-mentioned dimensions, which, instead of the Peacock's buoys, are used as winter entrance marks, and on account of this their special purpose not easily to be changed for less showing marks.

That we may effect the yearly shifting necessary for the inspection and thorough drying of the floating marks, we have two sets of buoys and perch buoys.

The reserve goods are kept in what are called buoy magazines, whose sight is chosen in such a manner that the distribution of the marks therefrom can be made speedily and conveniently. Such magazines are in Copenhagen, Dragör, Elsinore, Kallundborg, Svendborg, on the Isle of Lœsö, in Nobury and Sönderho, on the Isle of Fanö, at List, on the Isle of Amrum, in Husum, and in Horst, near Büsum.

All floating marks but the winter perch buoys are laid down in slack mooring, the length of which is determined according to the nature of the bottom, the force of the current, and the sea that in stormy weather most frequently prevails in the fairway. Hence, the moorings for the marks in the eastern district are always at least twice as long as the depth, and in the western about four times as long as the depth.

The winter perch buoys, because of the particular manner in which they are made to float, must stand in tight mooring.

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The mooring chain is 1¼ inch in diameter, and 20 fathoms long, the anchor is a flat, rough-hewn granite stone, of about 1,000 lbs. weight, to which a smaller stone of about 500 lbs. is backed by chain ¾ inch in diameter, and 15 fathoms long. The buoy seldom possessing power sufficient to stretch the moorings clain, of about 1,350 lbs. weight, and which ordinarily bores itself into the soft ground, and, through the thereby lessened swing room, easily is exposed to part under a gale suddenly sprung up; 3 or 4 buoys, of such supporting power that the chain is kept from sinking too deep in the sand, are distributed on a length of about 14 fathoms from the anchor stone.

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The buoys are made of iron plates riveted together, having three compartments, the one above the other, separated by iron platforms and united by angle rings. The two upper compartments are water-tight, and the bottom separating one from another has in the middle a hole, with a screw cover, of such a width that a man, in case of repair, may pass throug it. The lower very narrowed and funnel-formed compartment is, on the contrary, open beneath, in order to allow the entering of the water, the outer rim being, moreover, provided with small holes, through which the air is forced out by the pressure of the water by degrees as it rises in the compartment. The upper plate of the buoy, carrying the holster for the top perch, and being of the same diameter as the above-mentioned covered hole, is inserted in the upper angle ring by tap-screws and packed with cement. In the upper compartment of the buoy the plates are of $\frac{3}{16}$ths, in the middle of $\frac{4}{16}$ths, and in the lower of $\frac{8}{16}$ths-inch iron.

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In contradistinction to the iron nun buoys, a nun buoy, likewise constructed for floating in an upright position, of such a form as experience has proved the most answerable for nun buoys, and as generally the totality of the buoy material in the western district made of oaken staves.

In the buoys of this description the water penetrates into the ballast room through some holes made in the staves. * * * They are very striking, and are, as the above-mentioned iron nun buoys, made farther distinguishable by a top sign, generally consisting in a balloon of basket-make, or iron bands set up on a short perch.

As the iron nun buoys, these buoys are used for denotation of the most dangerous shoals, and, besides, for marking of the turning-points from the principal passages into their ramifications, but they are always taken in during the winter, as the ice otherwise would act detrimentally upon them. Some are then placed on perch buoys, or by six-feet nun buoys, floating in the ordinary manner, whose apex, however, is not provided with a top sign, such a one with difficulty living in the ice, whereas all the staves are close bound with hoop iron.

The mooring chain of the iron nun buoys is made of $1\frac{1}{4}$ inch chain. The anchor is a cast square-iron sinker, weighing about 2,500 pounds.

For the 13-feet nun buoys are used chains of $\frac{7}{8}$ inch in diameter, and for the 9 and 7 feet buoys chains of $\frac{7}{8}$ inch in diameter. The anchor for these marks is a somewhat flat, hewn granite stone, weighing at least 800 pounds.

The mooring chains for the other sea buoys, as for the summer or cask buoys, are $\frac{6}{8}$ inch in diameter, and the stone sinker weighs between 400 and 600 pounds.

For the winter buoys, are commonly used $\frac{7}{8}$-inch chains.

The stone-sinkers for the floating marks are either provided with an eye-bolt, soldered into a hole bored for the purpose, or encompassed with an iron band, provided with an eye for the shackling on of the chain.

The buoy for the summer perch buoys is five feet long, its bottom having a diameter of about three feet.

In the lower part of the buoy is a fixed bottom plate, adjusted, furnished, as the upright floating 13 feet nun buoy, with holes in the side for the flowing in of the water. Under the summit of the buoy is, moreover, hung up a so-named balance lead of 150 pounds weight.

In the log or winter perch buoy the log is not, as before, made of solid wood, but of water-tight fir staves, joined together, encompassed with iron bands. By this improvement this floating mark is made lighter, and made to ride better.

Of the perch buoys of this description the log perch buoy is the used, because it costs the least and stands the ice well. The c buoy is, therefore, only laid down on spots where the current is strong as to draw those under, or the bottom so steep-to that the perch buoy at tight mooring is exposed to the risk of being lost.

The length of the perches of the buoys do never exceed 18 feet on cask buoys, seldom 15 feet on the log buoy.

In the eastern district are used a few iron buoys of the same c struction as the Peacock's buoy, but to a lesser scale, for supportin perch of 18 feet with top signal. The marks ride excellent, but however, not to be preferred to the cask buoys, which are very dis guishable and by far less expensive than the iron buoys.

As the log or winter perch buoys are to float with the upper band of the cone in the very edge of the water, and thus have t laid down in a quite tight mooring, their dimensions are to be de mined according to the different depths where they are used.

The given dimensions are for a depth of 12 feet, such being the c nary depth in which perch buoys are applied in the pilot fairways.

In this depth the shackle fitted to the end of the root pole is directly to the sinker.

Is this sort of perch buoys, to be used in depths above 12 and tow 18 feet, only such a length of chain is shackled to as the respec depths exceed 12 feet; but from a depth of 18 feet and above it wil agreeable to the purpose at the same time to make the root pole the cone, each of them, two feet longer, and the diameter above of latter two feet greater.

Is the perch buoy laid down in more than 24 feet water; it is, m over, to be observed that the portion of the mooring longer than depth of 24 feet be made of rope, that the cone may have the powe bear the weight of the mooring. The rope is then shackled to the ch

For depths under 12 to 8 feet, the minimum in which marks of description are laid down, the nature of the ground for the rest b such as to allow of applying poles, from the length of the root pol the sketch are then to be drawn two feet, and from the length of the one foot, as the diameter of the cone at the upper edge can be th couple of inches smaller.

In order to diminish the top heaviness, the perch ought to be m a few, at least two, feet shorter, and the portion of the root pole sh ing above the cone six inches shorter and ⅛ inch smaller than show the sketch.

To the mooring chain is ordinarily given not above ⅝ inch in diam and the weight of the stone sinker ought not exceed about 900 pou

Concerning the durability of the totality of the floating marks, posing that they be managed and attended to as intimated abov may, as to the oaken buoys, especially the larger, be put down t years at least, and as to the winter perch buoys to about 12 years to the Peacock's buoys and the iron buoys, sufficient experience is as yet made in this respect.

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XXIX. None of the denoted distinctions prevail in the marking tem of the Monarchy, but the buoying of the pilot fairways, and of entrances to the harbors and roadsteads is ordinarily subjected to the respective pilot stations and harbor authoriaies, though generally under the control of the buoy inspectors.

As a general rule concerning the marking of the fairways with floating marks, observe—

IN THE EASTERN BUOY DISTRICT.

Entering into friths and passages, the direction of which is north and south, or east or west, the perch buoys, with black or red perches, coming from north or east, according to the direction of [illegible]rway are kept on the starboard, and those with white perches on the larboard side.

In the "Sound" all the buoys are laid down in the western side of the passages, numbered with white cyphers, as the list shows it.

Where the position of the perch buoy brooms is not mentioned, the brooms are bound upwards.

IN THE WESTERN BUOY DISTRICT, OBSERVE:

Entering from the sea into the passages, the black buoys and perch buoys with brooms are kept on the starboard, the white buoys and perch buoys on the larboard side.

The larger poles (spiirbaaker) are kept in the same manner.

The passage to Hjerting is in this respect considered as a continuation of Graayb, and the passage to Romö, Höierlöbet, and Listerlei as a continuation of Listerdyb.

The black buoys, only a few excepted, are bottle-shaped, and the white pointed at both ends. The black are denoted with white Roman chiffres, the white with black Roman letters. On the leading marks the name of the inlet for which they are placed is painted in Roman writing. These signs are applied in such a manner as readily to be seen from passing ships.

In the "Leierne," on the coast of Sleswick, the smaller poles (stikbaaker) coming from south are kept on the larboard hand. The entrance pole for each "Leie" is marked with two brooms, set horizontally.

A sea-mark having a balloon as top sign, the diameter of which being under 1½ foot, the same in the list is called "kurv," (basket.)

In the passages within the islands winter buoying is not kept; the poles, however, remain out, and are completed in the spring as far as they during the winter have been cut away by the ice.

The sands in this buoy district being frequently subjected to small alterations, one or more floating marks must very often be removed into other landmarks, hence the positions of the floating marks given in the list are not quite permanent.

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FLOATING LIGHTS.

The Method of Mooring.

The moorings consist of mushroom anchors of 3,300 pounds, with 165 fathoms 1½ inch chain, divided for convenience into 15 lengths; these lengths are shackled together in the customary way. To each mooring belongs a buoy chain ¾ inch in diameter, in order that the anchor may be weighed through it, further an iron buoy.

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Two common anchors, weighing 900 pounds, with two lengths, 90 fathoms 1-inch chain. In case of the moorings parting, the ship has either to seek the nearest harbor until new moorings can be sent her, or she may anchor at her ships' anchors.

The stations of the light-ships are too isolated to hold communication with the shore by any sort of signalling, the necessary communication being performed through their own tenders, of which each ship has two, or through coasting vessels in regular turns, paid by contract.

No life-boats attached.

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RUSSIA.

The Russian Hydrographical Department has the honor to forward the informations about the White Sea light-houses. The difficulty is in the translation, but if the reports about the state of the light-houses can be of any use, sent to the Royal Commision as they are, in the Russian language, they may be sent immediately.

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INFORMATION ABOUT WHITE SEA LIGHT-HOUSES.

I. The superintendent of White Sea light-houses is a naval officer, subordinated to the commander of the port of Archangel, and his technical part dependent from the Hydrographical Department.

The keepers are selected from the officers of the pilot corps.

II. All the materials are bought on the sums of Navy Department.

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HOLLAND.

STATEMENTS RELATIVE TO COAST LIGHTS AND PLACING BUOYS AND BEACONS IN THE NETHERLANDS.

Coast Lights, Buoys, and Beacons.

I. The management of the coast lights, buoys, and beacons, is solely in the hands of Government.

This management rests with the Minister for the Marine, under whom there is an inspector general and seven inspectors, (in as many districts,) who are charged with the direction and superintendence of this branch of the service. They are responsible to the before-mentioned minister

II. The costs for the construction and maintenance of light-houses, floating-lights, buoys, and beacons, are placed yearly on the list of Government expenses.

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IV. In the selection of positions for light-houses, the principle is generally adopted that the coast lights should, in the first place, be fixed in positions the most important to mariners as points of observation on shore, and, in the second place, be connected with the buoys which point out the entrances from the sea.

On account of the numerous lights on the coast of the Netherlands, which are placed in such a manner that the circle of lights intersect each other, or at least touch upon one another, there is no necessity for floating-lights in the outer roads or neighborhood thereof. They might easily become confused with the lights on the coast, or be placed too far within the circle of lights of one or other of the coast lights, and where they would be entirely superfluous.

But it has been long the conviction in the Netherlands that it would be of great service to navigation in general to place a floating-light in the North Sea, near the North Hinder Bank, eight leagues to the westward of the West Kapelle coast light.

In 1858 the North Hinder floating-light was placed. It furnishes in that position a most excellent point of observation for the passage of vessels which are proceeding from the North Sea to the English Channel and back; and it is further serviceable for touching at the coast of Holland and the sea entrances further to the southward. Its circle of light joins that of the large coast lights there.

V. In the Netherlands the following classification of lights exists, viz:

a. Coast lights.

b. River and shore lights.

c. Harbor lights.

The harbor lights, generally speaking, are only of local importance, and are excluded from the care of Government, appertaining to the direction of the authorities of the community where they are situated.

In this respect an exception is alone made when a harbor light is at the same time required for tidal navigation. * * * *

VI. In providing for the necessary service, two or three keepers are placed with each light, under one foreman, who is responsible for the proper care of the light to the inspector of the district who has the management of the lights.

Each river or shore light is attended by one keeper, under the superintendence of the inspector of the district.

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VII, X. For the purpose of distinguishing the coast lights, there are two kinds, fixed lights and revolving lights, as mentioned in the lists under Article III.

Flashing lights and colored lights are not made use of along the Netherlands coast.

XI. All the coast and inner lights, revolving as well as fixed, are catadioptric, dioptric, or catoptric, as mentioned in the lists in Article III.

The preference is given in this country to the catadioptric apparatus for lights.

XII, XIII. This apparatus is manufactured and furnished by Mr. Henry Lepaute, of Paris, according to the model by Fresnel. *

XIV. In order to make the improvements available which have been introduced from time to time in the apparatus for lights, they renounced the catoptric apparatus in the Netherlends for the dioptric, and then employed the catadioptric.

XV. Sixty Netherland ells (metres) above the level of the sea is considered to be the extreme height which should be given to a coast light;

although a height of forty-five ells (metres) is usually considered sufficient.

XVI. The best mode of ventilating the lanterns of the coast lights is considered and carried into practice by the introduction of air-holes into the lantern foot of those lights which light up to the entire horizon, and of brass ventilating slides in the dark divisions of lanterns for lights which light up only a portion of the horizon.

XVII. Purified rapeseed oil (patent oil) is used for the lights.

XVIII. No other kind of light is made use of for Netherland coast lights.

XIX. *a.* The rule is that the construction of light-houses, with the magazines and dwelling houses, according to a statement and drawing furnished, is publicly disposed of. A mode of proceeding generally employed in government works, and has produced a good result, because the execution thereof takes place under intelligent and careful superintendence by practical men.

The same method is resorted to for obtaining beacon tops.

The usual conditions by public tender for the various contracts, and for the construction of government marine works.

The stipulations are usually made with respect to the nature of the works.

The North Hinder floating light-vessel was built on one of the government wharfs. The same with the vessel in reserve.

The beacon buoys are constructed by and under the supervision of government. At a former period the attempt to allow private persons to execute the work produced no good result.

b. The illuminating apparatus for the lanterns of the coast lights are purchased in other countries. * * * * * *

The lanterns for the coast lights are manufactured in the Netherlands.

The apparatus and lanterns for the floating light, as well as for the vessel in reserve, were manufactured and furnished by W. Wilkins, manufacturer, in London.

c. In regard to the necessary maintenance of the work, amongst which painting is included, the contract is granted by public tender, (as mentioned under *a.*)

d. The stores are partly furnished from the marine magazines, partly bought of private individuals.

e. Organic lamps as well as reflectors for the illuminating apparatus are also manufactured in the Netherlands in a very satisfactory manner.

XX. The oil is tested as well by burning as by examination into the weight of similar qualities by means of the areometer.

Other stores are tested by comparing them with the patterns and models on hand.

XXI. Iron light-houses are painted every other year: wooden structures for lights every three years: floating light-vessels yearly; buoys and beacons twice a year. The materials for paint consist of white lead. yellow ochre, red lead, vermilion, and blacking. [lamp-black.]

XXII. Iron light-houses are painted the color of Bentheim stone; iron supporters for lights are painted black: wooden structures for lights, a bright yellow; and the lanterns for the coast lights are red outside and black inside.

The principal colors for buoys in the channels leading to the entrances from the sea are black, white , and red.

XXIII. When proposals are made for the introduction of improvements in the coast lights, buoys, &c., the Minister for the Marine gives orders for an inquiry to be made by practical men, who make a report to him of the result.

XXIV. On each of the coast light-houses are placed a thermometer: on board the floating-light a set of meteorological instruments, viz., a barometer, a set of dew point hygrometers, a psychrometor, and a deep-sea lead, with two thermometers.

XXV. The system mentioned here is not adopted in the Netherlands. Under certain circumstances alone, signals are made with flags and streamers by pilots vessels, to indicate at certain periods the height of the water in shallow parts of the entrances from the sea.

XXVI. In thick foggy weather the usual signals are made on board the floating-light by sounding the bell, preceded and followed by striking on the gong.

If any vessel, by pursuing a wrong course or otherwise, should be in danger of the sand banks, it shall be made known, in as far as possible, from the floating-light, by firing a gun and hoisting signal flags.

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As the size of the buoys differs greatly, and the ground tackle should be proportioned to their formation, and to the depth of the channels where they are placed, it is not possible to make a statement of the costs.

XXIX Coming from the sea, the white buoys are on the starboard side, and the black ones to larboard.

Red buoys are placed at the separation of two channels.

White and black in squares are buoys painted for the purpose of pointing out wrecks.

The objects for beacons placed along the outer roads of the sea entrances, such as the Flaaks, the Ooster, the Banjaard, are painted with vertical or horizontal black or red streaks.

The names of the sand banks are painted on the buoys.

XXX. Along the Banjaard are two iron (Herbert's) buoys, (iron inverted cone buoys.) Near the Schouwen sand bank there is an iron bell beacon vessel, (iron bell beacon buoy.) * * * *

Before the mud entrance (slykgat) of Godereede, and the shell entrance (schulpengat) of Texel there is a Peacock's life buoy, but which kind of object for beacons, with regard to its stability, has furnished fewer good results.

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There are no general instructions for the district inspectors. The regulations of the service conform to the local circumstances of each district. * * * * * * *

Besides the inspection of the district inspectors, a general inspection is made by the inspector general at times not appointed.

The maintenance of the buoys and beacons in the channels takes place by contract with parties who moor the buoys, and who are bound to provide a vessel with her crew fitted for the purpose on their own account, but who receive the materials for the buoys from the government magazines.

BELGIUM.

NOTE ON THE LIGHT-HOUSES (PHARES) AND HARBOR LIGHTS (FANAUX) OF BELGIUM.

The following is a translation of the return made by direction of the Belgian Government.

I. The construction of light-houses and harbor lights is part of the general administration of roads and bridges, (ponts et chaussées,) under the superintendence of the Minister of Public Works. An annual sum is carried to the budget of that department for the maintenance of the apparatus, the painting of the buildings, habitations of keepers, &c.

The "exploitation" of light-houses, that is to say, their illumination, depends on the general direction of the navy, to which the light-houses are handed over, when the administration of roads and bridges consider that they fulfil all the required conditions before they are put in action.

The general direction of the navy is under the orders of the Minister for Foreign Affairs.

The "budget" of the navy includes each year the sum necessary for the illumination of the light-houses, and for the payment of the persons concerned.

The light-houses of the coast of the North Sea are under the authority and the superintendence of the inspector of pilotage resident at Ostend. The floating light "Paarde Markt" is under the direction of the sub-inspector of Belgian pilotage, residing at Flesingen.

The inspectors of pilotage ought to assure themselves that the harbor lights are lit at the hour prescribed, and that they produce a clear and suitable light.

The subordinate staff of the light-houses, such as keepers, watchmen, and others, is subordinate to them, and they have the right to suspend them for five days.

Heavier punishments are inflicted by the general director of the navy, under a revocation which can only be pronounced by the Minister.

The buoys also form a part of the pilotage service.

The State directs the placing and maintenance by means of the inspectors of pilotage.

There are no beacons (balises) on the coasts of Belgium.

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IX. The colors adopted for the little fanaux are three in number, natural, green, and red colors.

XI. The apparatus of the light-house in construction is dioptric.

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XIII. The light at Ostend and the little fanaux of the coast of Flanders burn "l'huile à quinquet," (oil for Argand lamps,) perfectly purified.

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XVII. The oil which is used is oil doubly purified, like that commonly sold under the name of superfine oil, destined for carcel lamps.

XVIII. Oil only is used.

XIX. *a.* Buoys in Belgium are made of iron, under estimates.

b. Light-house apparatus is not the object of an adjudication.

The Department of Public Works addresses itself to the makers who seem to offer the best guarantee.

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The Departments of Foreign Affairs and of Public Works consult together when it is proposed to change the lighting of the coast.

XXIV. The meteorological observations are made in the light-houses.

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XXVIII. The buoys which are used in Belgium are not placed at sea, but in the interior, and in the Belgian portion of the Scheldt.

XXIX. The buoyage of the Scheldt is done by common agreement with the Netherlands. The buoys are black when the navigators ought to leave them to port in coming from the sea; white when under the same circumstances he should leave them to starboard. Only a few red buoys are used as yet, when the navigator may pass them indifferently to port or starboard.

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d, e. The mooring apparatus is composed of two anchors, of the weight of 17 quintals English, joined by a ground chain of 1⅝ inch English by 70 fathoms long.

In the middle of that chain is a swivel, to which another chain is riveted, of the same diameter, and of 120 fathoms long, passed through the hause-hole, fixed to the windlass, and finally in the chain well. It is hauled in and paid out as circumstances require. The lantern was made by Mr. Robert Wilkins & Son. Its diameter is six English feet; it has eight silver lamps, and shows a red light.

g. The lantern is hoisted to the mast in the ordinary manner by means of two chains, which pass through two blocks under the cross-trees, and which join and end in a single chain fastened to a hand-winch placed on deck.

h. The lamps turn on a universal joint, ealled cup and ball gimble principle.

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II. *f.* The vessel is provided with a series of signals, by means of which it communicates with the coast.

g. A life-boat which cannot be sunk is placed on the deck.

h. The crew is composed of eight men, of whom four in summer and five in winter are always present on board.

i. The master and the mate pass, turn about, a month on shore and a month on board. The sailors remain on board two months out of three. A supplementary sailor is engaged for the winter months, from October to the end of March.

j. The vessel quits her station every two years during ten days, to have her bottom scraped, cleaned, and repainted. The end of June is chosen for carrying out this work, or the first days of July.

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IV. The floating light has occupied her station from the end of 1848, and has never quitted it in consequence of any accident.

In February, 1855, the vessel was obliged to take refuge at Ostend in consequence of ice, but she resumed her moorings some days afterwards

AUSTRIA.

COMMUNICATIONS ON LIGHTS, BUOYS, AND BEACONS, ON THE AUSTRIAN COASTS.

I. The superintendence of all the light-houses, buoys, and beacons belongs to the Imperial Royal Admiralty.

The deputies of the Exchange at Trieste have to attend to the management of the light-houses, and they have to give their inferiors instructions in their sphere of action.

The duties of the deputation of the Imperial Exchange extend themselves to the erection of the light-houses, the repairs of the same, the pay of the men who are employed, and the discipline of them; their rights, on the other hand, consist in the collection of the legitmate light-house taxes and in the appointment of their own men.

The inferiors of the Admiralty have to attend on their own responsibility to the superintendence of the buoys and beacons.

II. All the taxes levied on commercial vessels belong to the treasury of the deputation of the Imperial Exchange Commission, in order to pay for the lights and all the necessary expenses, repairs, and renovations of light-houses.

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The costs of buoys and beacons are paid for out of the Imperial Treasury, after the receipt of annual estimate, submitted under the superintendence of the Admiralty, and after having been approved by the Imperial Board of Trade. These expenses, for which commercial vessels pay no charge whatsoever, amounted during 1858 to, altogether, 7,837 florins 74 kreutzers.

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IV. In selecting positions for light-houses, the Imperial Government is guided by the principle to facilitate as much as possible the navigation near the coasts of Austria washed by the Adriatic Sea; consequently, the most suitable positions are chosen by a commission consisting of shipowners, naval gentlemen, and the Imperial Navy, who, combined, are best able to point out the condition of the coast, but particularly, also, where possible, the entrance into the harbors and the positions of dangerously situated rocks or shallows.

* * * * * * *

VI. The number of assistants employed at the light-house of Trieste is four, and they have to signalize during daytime always the amount of sails and steamers in sight: at Salvore are two, and at all the others three are appointed.

The harbor light at the point of the mole of Fiume is attended to by the authorities of the place, together with the lighting of the town.

* * * * * * *

IX. There are at present in use only the two colors, white and red.

X. At the light-house near Rovigno the red flashing ray is used, because it is situated between and not far from the two light-houses of Salvore and Porer, both of which have white fixed fire: and at Rovigno are quartered also the Austrian coast pilots.

XI. The various apparatus were mentioned in VIII. The catoptric apparatus à la Fresnel were taken as the best, since they consume the smallest quantity of fuel, and furnish at the same time the finest light, on which account they are introduced gradually everywhere.

XII. Mr. Henry Lepaute, at Paris, is the maker of the most approved catoptric apparatus à la Fresnel, and the drawings may be had from him.

* * * * * * *

XIV. The selection of the different optical apparatus is arranged according to the principle expressed in X.

XV. The circumstances of the locality are taken into consideration respecting the utmost height of the light-houses, with especial calculation for the fog caused by the easterly winds, on which account the height of the same at the eastern coast of the Adriatic ought not to be above 400 feet.

XVI. The most approved kind of ventilation seems to be that of the light-house of Lagosta, which consists of eight openings, supplied with bronze covers, and which may be closed and opened at pleasure.

* * * * * * *

XVII. They burn usually fine olive oil. But for the lights à la Fresnel, they use the olive oil named *fior di pila,* which is imported from Istria and Dalmatia, because it is not so fat.

XVIII. No other kind of proceedings is applied for the production of the light but olive oil.

XIX. The light-houses are erected according to circumstances, partly by private agreements, partly by means of public tender, and partly by the Commission of the Exchange themselves, and private contracts seem to be the most economical, and in most cases, also, to have answered best.

The light apparatus à la Fresnel are ordered from Mr. Henry Lepaute, in Paris.

The Argand lamps, together with the reflectors, and what else belongs to the same, are made by M. Giovanni Rosario, at Milan.

The Commission of the Exchange attend to the paint and other stores as they think best.

The buoys and beacons are, according to the contract, in the Stabilimento tecpico Triestino. The anchors and chains which may be necessary are ordered from the works of Mr. H. Wood, in Liverpool.

* * * * * * *

XX. An employé of the Commission of Exchange pays every year an official visit to all light-houses, in order to convince himself of the perfectly good keeping of the same, as well as of the light apparatus and of the whole furniture, and in order to propose necessary repairs, alterations, &c. At every light-house is kept a list of all articles there, which must be strictly correct at all times.

XXI. The light-houses are usually once in two years whitewashed inside with lime.

The chamber of the light apparatus is painted white with oil paint, and the cupola green with oil paint.

The buoys and beacons are coated once in six months with red oil paint, (minimum,) which, after repeated trials, seems to answer best as a means to preserve iron, or sheets of iron, placed in the water.

The piles are painted every year once from the level of the water upwards with tar.

XXII. Hitherto all light-houses have been painted in one way, but they will be painted in the future, most likely, white and red, or somewhat similarly, in order to enable the navigators to distinguish one from the other easily from the distance.

XXIII. Every renovation or alteration of a light apparatus is to be first submitted for approval on the part of the Admiralty by the Commission of the Exchange; and every new introduction is to be examined previously by a commission.

As to the buoys, beacons, and piles, the proposals for all needful increase, alterations, or improvements, repairs, &c., are to be made by the employés of the Admiralty.

XXIV. Every light-house is supplied with a thermometer and a telescope, respecting which the keepers have no printed rules.

XXV. Since the difference between tide and flood is small in the harbors of the Adriatic, amounting to from three to four feet at the utmost, the height of the water is nowhere reported.

The local circumstances of the harbor of Malamocco, where the current is very considerable, as well during the flood, demand particular care on entering, especially if the wind is strong and contrary; and, therefore, the pilots stationed there announce to ships which are about to enter, the most useful signals by means of three flags—a red, a blue, or a white one.

The red flag hoisted on the pilot ship designates:

You are not able to enter; retire.

The blue one:

Presently you will be able to enter, till then withdraw, and remain in sight.

The white one:

You may enter; we start to meet you.

At night time the red flag is replaced by two Bengal lights, the blue one by one Bengal light, and the white flag by means of a lantern, which is drawn up and down frequently.

XXVI. At the extreme point of the large northern dam of the harbor of Malamocco is situated an iron scaffolding of the height of 42 feet which is supplied with a kind of clockwork, which is wound up when a fog happens to arise, and which signalizes to ships, by means of strokes upon a gong, the entrance into the harbor.

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